# CERAMICS

JUNE
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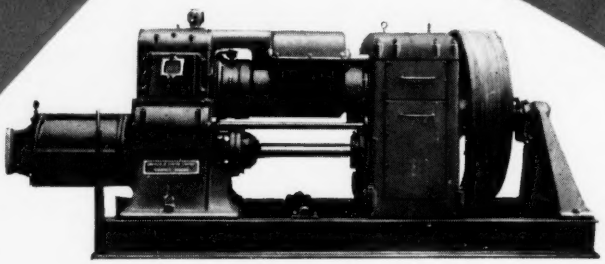

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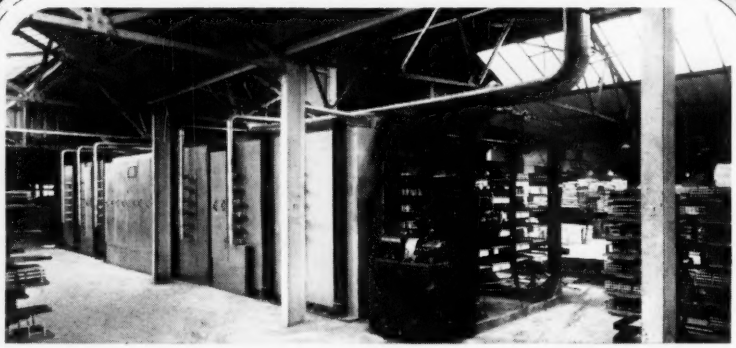

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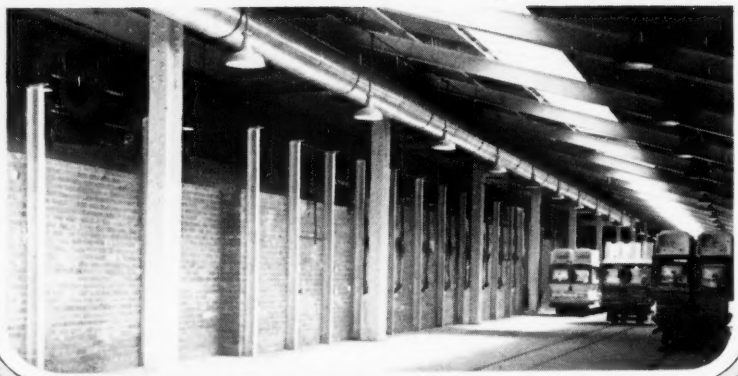

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# CERAMICS

## JUNE, 1951

*EDITOR*

W. F. COXON, M.Sc., Ph.D., F.R.I.C., F.I.M.

A monthly journal covering the whole ceramic field including pottery, glass, heavy clay, refractory and silicate industries.

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### FEATURE ARTICLES

| | *Page* |
|---|---|
| EDITORIAL ... ... ... ... ... ... | 175 |
| THE MOVING FINGER WRITES . . . By Argus ... | 177 |
| EXCESS AIR—IMPORTANCE IN FIRING AND ITS CONTROL ... ... ... ... ... ... | 181 |
| BRITISH POTTERY MANAGERS' AND OFFICIALS' ASSOCIATION—THE INDUSTRIALIST IN SOCIAL EVOLUTION. By C. Bailey ... ... ... | 190 |
| LOWERED STATUS OF TECHNOLOGICAL EDUCATION. By W. F. Coxon ... ... ... ... ... | 201 |
| REFRACTORY MATERIALS IN GAS MAKING PLANT. By T. M. Firkin ... ... ... ... ... | 215 |

### MISCELLANEOUS

| | |
|---|---|
| CERMETS ... ... ... ... ... ... | 189 |
| PHOTOMETRIC DETERMINATION OF ALKALIS IN PORTLAND CEMENT ... ... ... ... | 199 |
| AUTOMATIC METHODS IN POTTERY MANUFACTURE | 209 |
| STANDARDISED LABORATORY GLASSWARE ... ... | 210 |
| BRITISH IRON AND STEEL RESEARCH ASSOCIATION | 222 |
| CLASSIFIED ADVERTISEMENTS ... ... ... | 228 |
| ADVERTISERS' INDEX ... ... ... ... | 228 |

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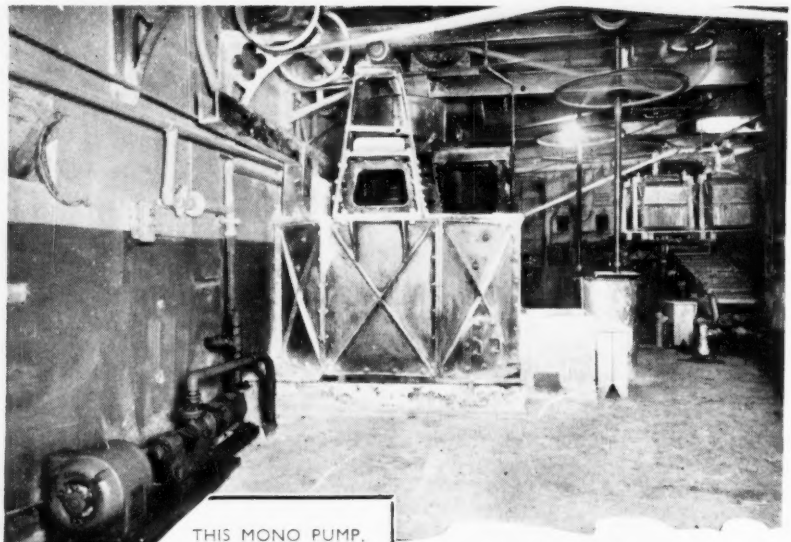

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Ceramics

VOL. III JUNE, 1951 NO. 28

# THE CALM BEFORE THE STORM

THE Roman politicians kept their unruly mob from pondering upon things that mattered, by bread and circuses. It is surprising what little originality the politicians show as dynamic civilisation rolls on!

Today there is a tremendous under-current of industrial unrest. The "phoney" cost-of-living index means nothing to the man in the street. He sees prices of goods in steep ascent; he sees wages lagging behind; he sees industrial production dammed by restrictive practices of all kinds. Recently 1,000 manufacturers were questioned and the replies showed that engineering, clothing, housing, and the paper trades were calamitously hit by shortages of steel, sulphur, cotton, glass, timber, bricks and paper. Supplies of steel have been cut in many cases 50 per cent. in six months; 50 per cent. output losses because of dwindling tin supplies; the piling of heavy loads of steel plate because of absence of railway waggons; galvanized wire makers with an 80 per cent. reduction of material; prices of paint pigments showing 400 per cent. increases in a few months; ruination of fine quality glass exports by insufficient thin paper for protection; serious shortages in American and Egyptian cotton.

All of which adds up in the end to unemployment and a depression. The politician and economist can blissfully shrug their shoulders but even the thickest rhinocerous hide cannot disguise the fact that now it is goods chasing money rather than money chasing the goods.

The repercussions on industry are shown by the disgruntlement of the rank and file member of the various trade unions. And what indeed, does the politician offer instead of unified, sensible and serious direction and co-ordination?

Why, of course, it is the old bread and circuses, but this time we call it the Welfare State and the National Fun-fair!

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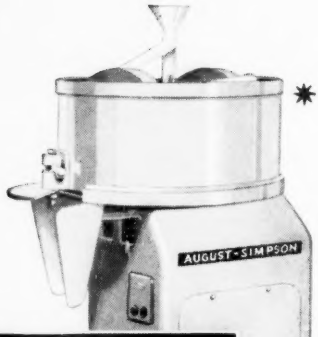


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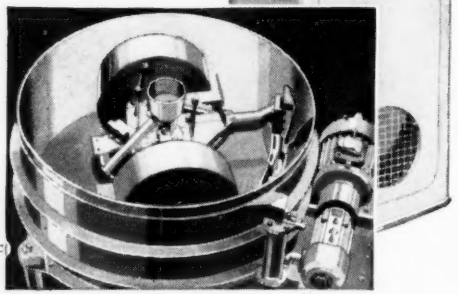

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# THE MOVING FINGER WRITES . . .

*by* **ARGUS**

WHEN things go wrong, as they always will do, and always have, in human relations, some scape-goat must be found for the political heads of every country concerned. At present all our woes are attributed to stock piling although stock piling is merely the first sign of a long-term trend in the world economy.

**A Steadying Thought**

In 100 years the world population has increased from 1,000 million to nearly two and a half thousand million, and is now increasing at 20 million a year. It is a steadying thought to realise that every two and a half years the world population increases by a number equal to the present population of the United Kingdom! In the past 100 years the use of iron and steel have multiplied five times as fast as the population. Since 1880 copper is up ten times and zinc five times in consumption. If the amount of copper used per head of population of the world rose to half that used in the United States, the world would need five times its present production!

Figures like these show that shortages of raw materials are by no means transient. There was a time when these could be dug out of the ground in the remote corners of the world at low labour rates resulting in a comparatively low price to the industrial nations of the world who fabricated them and sent them back for use as finished commodities.

That circumstance is far behind! Now nations preserve their raw materials for their own use or bargain them at the highest price in return for other things. Disparity in the standard of living of the white man, the black man and the yellow man is closing up. For the teaming millions of Asia to increase their average life-span from about 25

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years to 30 years would increase their population rate and cannot help but affect the economy and standard of living of the civilised world.

Perhaps therefore the most vital problem to which research and development can be applied is that of conserving raw materials and obtaining them from sources which in the past were uneconomical.

Professor A. J. Murphy, M.Sc., made these points in his presidential address recently to the Institute of Metals.

They are far-reaching by implication, but we would be well advised to realise the substance of the claim.

Britain might in the past have lost every battle until the final one, but the threat to Britain with no material resources except coal and a disproportionate population of high standard of living compared to these limited natural resources presents a problem of the next fifty years. Literally, it is a life and death struggle, and instead of being together on a concerted approach in the face of this national problem we are divided by political party spleen on the price of fish, the availability of spectacles and red herrings in general. The problem demands action by men of foresight, men of industrial experience and men who live by wealth production—the book of the dilettante Victorian politician or the modern political economist is closed never again to be opened!

**The South Bank**

Incidentally I wandered over the South Bank the other day and spent much time in the Dome of Discovery. There has been a tendency for the critics of the Exhibition to close up and say nothing derogatory because it is not considered "in the national interests."

Let me begin by saying that my overall impression of the Exhibition was that it was excellent—and I am hard boiled as far as exhibitions! But this impression was of the exhibits themselves rather than some of the grotesque monstrosities presented by our contemporary architects. But this can be overlooked in the commanding interest of the exhibits themselves. After all, austere architectural façades are merely the modern fashionable clothes which bedeck the greatness of British prestige and accomplishment—and fashions change. I read Gordon Russell and heard Mr. Cusson the Dome architect, and they confirm the impression one gathers from the show, namely that the organising authorities began with the Festival's architectural dress and then placed the exhibits in position. Remember also that most of the exhibits are the exhibits of private enterprise and private industry and would be looked at and appreciated anywhere in the world irrespective of the architectural background.

**Dome of Discovery**

Of the Dome of Discovery its architect, Mr. Cusson, talked on television. He referred entirely to its architecture—which to my mind is hideous whilst the exhibits seemed unimportant to him. Mr. Cusson has rendered the Maze at Hampton Court obsolescent overnight. What is more he has covered his maze with an aluminium skin, which one must admit is very clever although somewhat expensive. The interior of the Dome of Discovery has all the hall-marks of the kind of exhibit you see at open days, and so on, in the various Government Research Departments. Their stereotyped notices "Do not Touch," the rather tawdry pieces of paper labelling the exhibits.

For example, there is a model describing the periodic system of elements in chemistry laid out for the comprehension of the layman. One viewer having covered a five year course of study on chemistry and obtained a first-class Honours Degree confessed it was incomprehensible to him. He apologised and

said maybe he should have studied chemistry at an Art School. There were showcases containing exhibits without labels, and there were empty cases with labels. The platitudes and aphorisms about Britain which we have heard so often brought nostalgia. An apparatus demonstrated Maxwell's work. It had a card "Do not touch" and a press-button which said "Press here." The exhibition of electroplating was frankly a disgrace. The samples were pock-marked and dusty. The articles themselves would not reach the imagination of the Continental or the American. The nationalised cable and wireless showed that to send a cable from Cyprus to Accra cost 9s. a word in 1887 and now it costs only a 1s. So what? A pint of beer cost a penny then and now it costs 1s. 6d. Much better progress! A case demonstrating an atomic pile was captioned but empty, reflecting either burgling activities which had escaped M.I.5 or our State's state of knowledge. Crystals of copper sulphate were labelled as "copper."

The point is that the exhibits in themselves were of intense intrinsic interest, but I would say to Ian Cox the Director of Science for the Festival that there has been no co-ordination whatsoever in the layout of exhibits in the Dome of Discovery. All have concentrated upon the architectural side and neglected the layout of the exhibits themselves. Explanations were few and far between. There was not even an attempt to standardise on showcases. Some were painted and some were not. Obviously any old cupboard with a glass front had been dragged out of Whitehall and its ancillaries and considered good enough for the job.

**Still Time**

I write these remarks quite unchastened. The great mass of visitors to the Festival has not yet descended upon us, and there is time for some concerted action at least to categorise more clearly the sections in the Dome of Discovery, to offer better explanations possibly in French, German and Spanish as well as English, and to get out an attractive and clearly defined labelling scheme.

Maybe the commissionaires who stand around and tell people they cannot go up this way or they cannot go out there, or put out that cigarette, might be supplied with a little brush with feathers, so that they could occasionally dust themselves and the exhibits.

**Impersonal Attitude**

One could not care less about the architecture for all of that will be pulled down, but within that Dome of Discovery there is a tremendous amount of material which reflects the work of the distinguished thinkers and practical workers of Britain, and it has been very inadequately demonstrated. One only has to enter the gates of the Exhibition to feel that cold impersonal attitude which permeates anything organised by a Government department.

The whole South Bank is designed for you to start at point A and then work your way through in a manner which the designers want. But when you go to an exhibition, it is a day off; you want to wander at will, seeing what strikes your fancy. We are shepherded enough already without paying 4s. or 10s. to be shepherded to such a concentrated extent. In the Dome of Discovery you can follow it around in the normal way as the Pundits would have you do, but if perchance half-way round it is necessary that one should find the mundane cloakroom, one truly appreciates the maze which Mr. Cusson has unwittingly perpetrated, for you have to walk about 100 yards and climb three staircases to cover a distance of 20 yards as the crow flies.

The Exhibition is a first-class show. The exhibits are well worth seeing and it does portray the many

things we have done in Britain which we tend to overlook and not talk about, but which many other countries blazen to the skies as their own discoveries. Just forget the architects with their pointed beards and concentrate on the things that matter. All the organisers seem to have done is to render more difficult the task of appreciating the innate individuality and characteristics which made Britain great.

**Coal Prices**

And talking of individuality the recent press release from the National Coal Board on zoned prices for house coal reaches the lowest ebb in individual choice. The country will be divided into sixty "consuming areas or zones" but in spite of this the farther away you live from Britain's one natural resource, the more you will still pay for coal. And even if you live next door to the pit you will be lucky to get it at less than £5 per ton. Lower summer prices are there to induce southern consumers to stockpile presumably by the obsolete practice of using the bath—for in the new blocks of flats little other storage space has been provided.

Although the statisticians have carefully grouped coal into eight quality groups, they are quick to point out that this variety will by no means be available in any particular zone!

Basically the result is that we have sixty zones and eight quality groups with eight different prices and different prices in each zone, and it would be advisable to store coal in the summer, if you can get it or if you can store it! The whole thing seems pretty well the same as it was prior to the boys in Hobart House having done a little statistical work when their services would have been much more appreciated at the coal face!

Coal Board Executives and Coal Board Statisticians are ten a penny but miners seem to be a fast diminishing species!

## A SOLAR FURNACE—FOR HIGH TEMPERATURE RESEARCH

A SOLAR furnace, which by using the radiant energy of the sun, is able to produce extremely high temperatures in a small area, originally designed for General Motors Corp. of America in co-operation with the Aluminium Co. of America is at present mounted at Rockhurst College, Kansas City.

With an aperture of 120 in. and a short focal length, 34 in., parallel rays from the sun are concentrated into a small area near the focal point of a parabolic mirror, producing an image of the sun $\frac{3}{8}$ in. in diameter. Attainable temperatures are somewhat less than the apparent temperature of the sun, 6,000° C., due to energy losses.

The furnace has been found most effective for the study of refractory substances—for determining their melting points, discovering high temperature modifications, and for producing and studying possible glass forms of refractory oxides. It is also being employed in an attempt to extend the internationally accepted temperature scale and in the development of new high temperature materials.

There are of course obvious limitations; the small heating area provided and the fact that unfavourable weather hinders or prevents use of the furnace. However, many advantages are offered to those engaged on research. Substances are heated under very pure conditions and in an oxidising atmosphere, while the addition of a quartz-glass attachment will permit work in a reducing or neutral atmosphere, or in a vacuum. Electric or magnetic fields, gases or fumes which might disturb reactions or spectra studied are absent. A temperature of 2,500° C. is reached in 10 seconds, yet cooling is also rapid.

(*Amer. Cer. Soc. Bull.*, May, 1951.)

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**Acheson Colloids Ltd.**—Mr. W. E. J. Cross, A.I.Mech.E., Midlands Engineer of Acheson Colloids Ltd., London, manufacturers of the well-known "dag" dispersions, has moved his office from Great Barr to Victoria Buildings, 5th floor, Corporation Street, Birmingham. Telephone No. Midland 3287.

# Excess Air—Importance in Firing and its Control

(SPECIALLY CONTRIBUTED)

IN the combustion of carbonaceous fuels a series of chemical reactions occurs resulting in the oxidation of carbon compounds to carbon monoxide and carbon dioxide, while combined hydrogen is converted to steam, e.g.

$$CH_4 + 2O_2 = CO_2 + 2K_2O$$

methane + oxygen = carbon dioxide + steam

Where air is used for combustion the nitrogen passes on unchanged to give a gaseous mixture of steam, carbon dioxide, and nitrogen.

It will be seen from the above chemical equation that there is a definite quantity of oxygen or air which suffices to complete the combustion, and this quantity is sometimes referred to as the "theoretical" air.

## Calculation of Stack Gas Composition

With the aid of chemical equations one can calculate the composition of the resulting gas when definite quantities of the chemical elements are burnt in air (Table 1).

Using these factors it is possible, knowing the chemical composition of the fuel, to calculate the volume of gaseous products resulting from the complete burning of unit quantity of fuel, and also the percentage carbon dioxide in the flue gas. With bituminous coal of calorific value of approx 14,000 B.Th. U. per pound the percentage carbon dioxide in the flue gas is of the order of 18·5 per cent. and corresponds to combustion with zero excess air. Obviously use of more than the theoretical quantity of air will dilute the carbon dioxide in the stack gases and the percentage will fall. In this case 50 per cent. excess air gives a value of 12·2 per cent. carbon dioxide, 100 per cent. excess air reduces it to 9·1 per cent. and so on. It is apparent, therefore that the carbon dioxide content of the stack gases gives a means of following the combustion conditions.

Unfortunately it is only possible to realise the ideal conditions of

TABLE 1

| | *Theoretical air required per lb. of fuel* | *Cubic ft. of gas formed at NTP per lb. fuel* | | | |
|---|---|---|---|---|---|
| | | $CO_2$ | $H_2O$ | $SO_2$ | $N_2$ |
| $C \longrightarrow O_2$ | 11·5 | 31·4 | — | — | 119·0 |
| $H_2 \longrightarrow H_2O$ | 34·24 | — | 188·0 | — | 353·0 |
| $S \longrightarrow SO_2$ | 4·31 | — | — | 11·5 | 44·0 |

TABLE 2. HEAT LOST IN WASTE GASES AT DIFFERENT TEMPERATURES AND WITH DIFFERENT PROPORTIONS OF EXCESS AIR

(expressed as percentages of heat available from coal with C.V. of 14,000 B.Th.U./lb.)

| *$CO_2$ %* | 18·5 | 12·2 | 9·1 | 7·2 |
|---|---|---|---|---|
| *Excess Air %* | 0 | 50 | 100 | 150 |
| 500° C. | 22 | 30 | 38 | 46 |
| 1,000° C. | 43 | 60 | 77 | 94 |
| 1,200° C. | 52 | 73 | 95 | — |
| 1,400° C. | 63 | 88 | — | — |

combustion where complete mixing of fuel and air can be achieved, and in actual practice some excess air is always present.

### Excess Air Wastes Heat

From the point of view of the efficient use of fuel it is important to keep this excess air to the lowest limit possible consistent with satisfactory firing, since it extracts heat from the combustion zone and passes it to the stack, and the higher the firing temperature the more serious is the loss. This is illustrated by figures published by E. Rowden, W. Noble, and A. T. Green (*Refractories J.* **20**, 89, 1944) and given in Table 2.

### Heating in Ceramic Industries

There are two main types of heating to be considered:

(a) Steam raising—usually for heating drying floors and other forms of dryer.

(b) The actual firing of clay goods to bring about the necessary changes giving strength to the fired ware.

In the first type of heating it is possible to keep a close check on the excess air and by controlling it, to achieve the most economical firing conditions. In the second we are not so fortunately placed, for some excess air must be admitted to the kiln over and above that required for combustion of the fuel and the heat loss accepted. It has been stated that in an intermittent pottery oven 50 per cent. excess air is necessary.

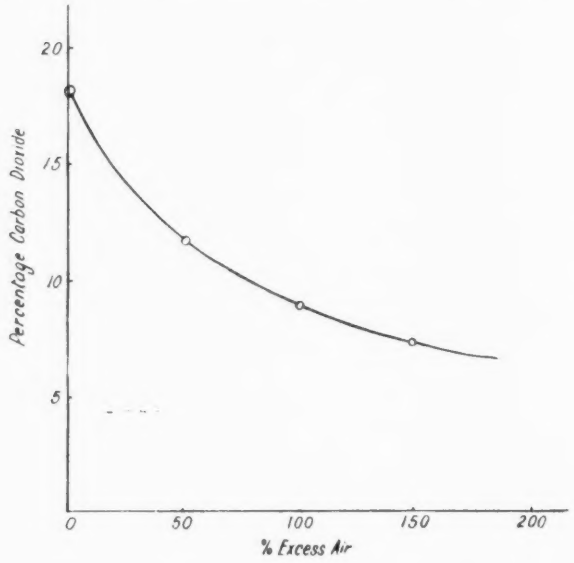



Fig. 1. An example of graph for the determination of percentage excess air used

### Excess Air Necessary for Drying

Thus in the early stages when goods, which are set wet in the kiln, are being dried out, sufficient air must be used to remove water vapour and prevent it condensing on the goods in the colder parts of the kiln. If this is not done we may get ware going out of shape due to softening of the clay by moisture ("morted" ware) or scumming due to the action of moisture and acid kiln gases forming sulphates on the surface of the goods.

At a later stage, approximately 500°-800° C., sufficient air must be present to complete the oxidation

of all carbonaceous matter in the ware otherwise black cores and blistering may result, or pink centres in buff ware. At the same time chemical dehydration of the clay molecule liberates large volumes of steam which must be cleared by admission of plenty of air or it will be impossible to get complete oxidation of the carbonaceous matter.

**Too Much Excess Air Often Used**

While some heat loss is thus inevitable it is quite certain that in firing intermittent ovens much more excess air is often admitted than is necessary, and the aim should be to reduce this loss of heat. Fortunately the chemical changes referred to above occur in the earlier stages of firing, when heat losses are not as serious as they would be at higher temperatures. Nevertheless proper attention to the firing, particularly in the later stages, should show appreciable savings of fuel, and in these days of rising fuel prices this is a matter of importance.

Since in intermittent ovens there are usually no means provided for heat recuperation, it means that in order to bring up the whole of the setting to the required finishing temperature the gases leave the oven at temperatures in excess of 1,000° C. and with large amounts of excess air it may prove impossible to reach the required temperature.

**Determination of Percentage Excess Air Used**

It is evident then that some method of determining percentage excess air used in firing is a valuable aid to efficiency. It is usually done by constructing a graph of the percentage carbon dioxide in the stack gases against excess air used. A typical example is given in Fig. 1. The values are calculated from the chemical analysis of the fuel in the manner indicated above.

Having constructed the graph for the fuel being used, a sample of the furnace gas is analysed, and the percentage carbon dioxide found. From this the graph gives the corresponding percentage excess air being used at the time the reading was made.

The gas analysis is made in an Orsat apparatus or some other similar type. Briefly the measured gas sample is passed through a series of solutions which absorb oxygen, carbon monoxide and carbon dioxide, and the decrease in volumes are noted. From this the percentage of carbon dioxide in the sample can be found. Taking the gas sample and analysing it is a time-consuming job, which can only be done by trained personnel and at infrequent intervals. It is useless for continuous recording of the firing conditions.

It is a matter of common experience, particularly in firing ovens which are stoked manually, the conditions change radically as the oven is baited, and as the fuel burns down in the firemouth leaving a space over which air can get into the oven unless attention is given to firedoor and regulators, and unless these fit well.

**Excess Air Drawn in Over Fires**

Dinsdale and Francis (*Trans. Brit. Ceram. Soc.* **44**, 1, 1945, cf. CERAMICS **1**, 624, 1950) investigated the conditions in an intermittent pottery oven and showed that the excess air entering the oven increased rapidly as the fuel burnt down on the bars, giving serious heat loss, as reflected in the oscillating temperatures recorded.

For proper control of firing therefore, some continuous record of the carbon dioxide content of the flue gases is preferable to tests taken intermittently. It is possible to fit an apparatus into the stack to give a continuous reading of the carbon dioxide content of the stack gases at some central control point, where it can be mounted on an instrument panel with temperature recorders, draught gauges, etc.

**Continuous Records of Carbon Dioxide Content of Stack Gases**

The apparatus depends on the difference in thermal conductivity between air and carbon dioxide. If a constant current is passed through a wire surrounded by a gas in a closed cell the temperature of it will rise until a state of equilibrium is reached, when the heat supplied to the wire balances that lost by heat conduction through the gas. In a gas which is a poor heat conductor the temperature of the wire may be expected to be higher than when a good heat conducting gas is used. An instrument for measuring the carbon dioxide content of a gas, electrically is constructed on this principle (Fig. 2).

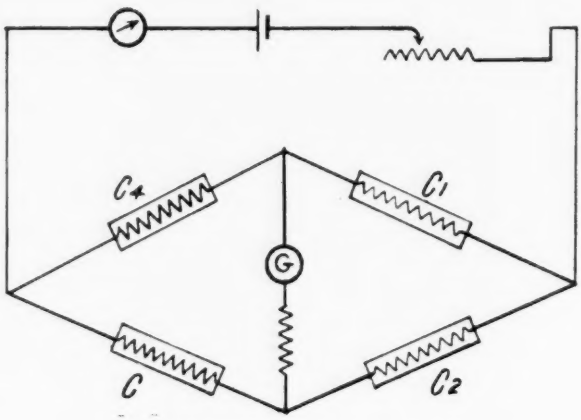



Fig. 2. Instrument for measuring the carbon dioxide content of a gas electrically

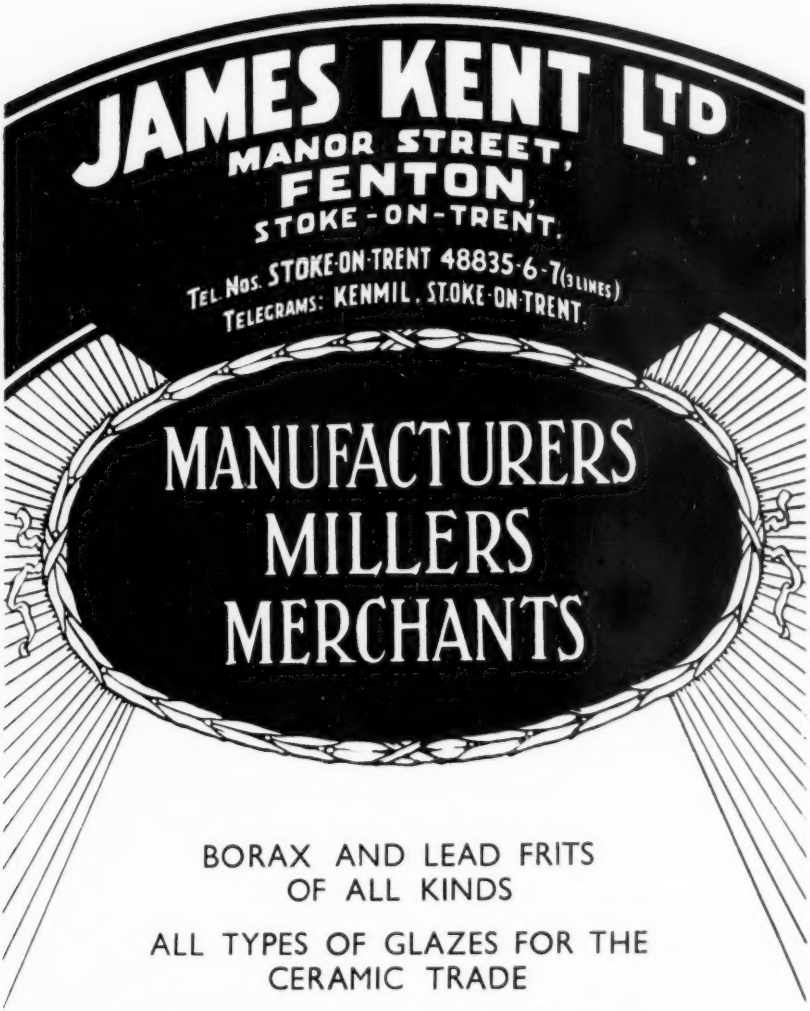
It consists of a Wheatstone Bridge whose four arms are made up of metallic cells each containing identical platinum resistance wires. ($C_1$, $C_2$, $C_3$ and $C_4$ in Fig. 2.) These are enclosed in a solid metal block which serves to maintain both sides of the bridge at equal temperature.

If therefore $C_1$ and $C_3$ are filled with air, and $C_2$ and $C_4$ with a mixture of air and carbon dioxide, and a constant current is passed through the circuit then, due to the difference in conductivity of the gases, the platinum wires will attain different temperatures. The electrical resistance of platinum wires varies with temperature and so the Wheatstone Bridge will be thrown out of balance as indicated by a deflection in the galvanometer G.

The extent of this deflection will depend on the amount of carbon dioxide in the air-gas mixture, and by using known amounts the instrument can be calibrated to record directly the percentages of carbon dioxide present in the flue gas. Differences in moisture content are eliminated by saturating the gases in each cell with water vapour and the effects of different amounts of nitrogen and oxygen in the stack gases are without serious effect as the conductivity of these gases is very similar.

**Soot is Filtered Out**

The gas sample is drawn from the flue by an aspirator unit through a soot filter, and through water which removes harmful gases which might damage the apparatus and also saturates the gas with water. The carbon dioxide meter is connected electrically to the recorder. Where A.C. current is available the apparatus can be operated with a

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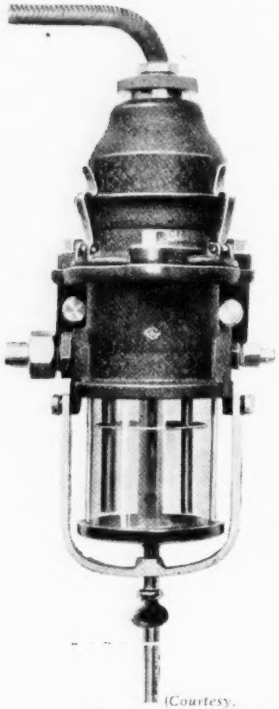
unit rectifier which dispenses with batteries. This is very useful on continuous recording units.

When samples are taken at a number of points it is necessary to install a $CO_2$ measuring unit (or Katharometer) at each point, but the readings can be recorded either visually or on charts at a central control point.



(Courtesy, Cambridge Instrument Co. Ltd.)

Fig. 3. $CO_2$ measuring unit, showing glass bubbler through which gas is drawn to saturate it. Electrical equipment is in upper part

Clock or electrically driven chart recorders are available for single or multiple records, while multipoint visual indicators are available usually in 6, 12 or 18 point installations.

Where it is also required to determine the combustibles in the stack gases as a further check on efficiency these are burnt to carbon dioxide in a special electric furnace and the carbon dioxide determined in the gas sample before and after burning. The increase in carbon dioxide content is a measure of the combustible gases present and is recorded as such. The whole unit is compact and incorporates the electric furnace and two $CO_2$ measuring units, one for the $CO_2$ content proper of the stack gases, and the other for measuring the combustible gases.

**Portable Unit**

An alternative to the permanently installed $CO_2$ recorder is the portable unit. It consists of a pump for withdrawing the sample of gas, and the measuring unit, which is of course battery operated. The sampling tube incorporates a thermocouple for measuring the temperature of the gases, the same galvanometer on the $CO_2$ meter being used as a temperature recorder with a separate scale.

Such an apparatus is very convenient for enquiries and it can be used for checking other instruments. It can be used for checking the heat loss to the stack by the approx. formula:

$$H = \frac{k(t_2 - t_1)}{C}$$

where H is the percentage heat lost, $t_2$ is the stack gas temperature in °F. $t_1$ is the boiler house temperature in °F., C is the percentage $CO_2$ in the stack gases, k is constant depending on the fuel composition. For average steam coal this is 0·38, for anthracite it is 0·42.

For daily comparisons using the same fuel:

$$\frac{H_1}{H_2} = \frac{(t_2 - t_1)_1}{(t_2 - t_1)_2} \cdot \frac{C_2}{C_1}$$

This provides a useful check on day-to-day firing, especially when taken in conjunction with results of percentage combustibles in the ash.

Instruments of this kind are now widely fitted on modern boiler plant and on some large continuous brick

kilns. Most intermittent ovens and furnaces are still fired manually without the aid of instruments, the view being in many cases that as opportunity occurs the oven will be scrapped in favour of continuous tunnel firing, where the heat will be recovered and used, so that waste gases pass up the stack at very low temperature.

Much can be done, however, on old kilns and boiler plants to reduce heat losses by excess air without the use of instruments though the exact control of firing conditions is lacking. Anything which cuts out leakage of unwanted air into the furnace is an aid to fuel saving.

It is too infrequently recognised that on boiler plants and furnaces and ovens a considerable amount of air leaks into the plant through cracks in brickwork or through badly fitting furnace doors and regulators. Leaks in brickwork can be traced quite simply with a candle or an open flame lamp moved along the brickwork. These should be marked with chalk or paint and subsequently stopped up. The same simple apparatus can be used for investigating firedoors and regulators. If these fit badly they should be replaced by new ones or altered.

The materials used for plugging cracks will vary with the location. On boiler installations and kilns brickwork can be stopped with a mixture of asbestos and fireclay with sufficient tar to give a kind of putty. After sealing cracks in brickwork several coats of tar may be applied to seal the structure, especially as brickwork can be quite porous. Damper slots often fit badly due to movement of brickwork. Replacement with ones moving in a metal framework may be advantageous. Inspection doors should be sealed with asbestos rope gaskets and luted with fireclay. The air grids on firedoors are often too big and may require modification. An expert should be consulted on this. The grids should not be left open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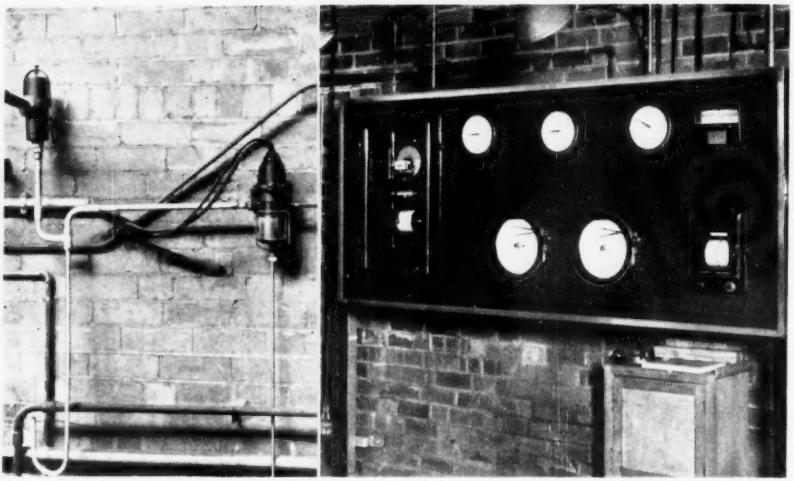

(*Courtesy, Cambridge Instrument Co. Ltd.*)

Fig. 4. Installation at S. Smith and Co. Ltd., Brewers, Tadcaster, showing $CO_2$ indicator and recorder, $CO_2$ metering unit, and draught gauges

unnecessarily, and with fuels low in volatiles like coke and anthracite they may be left closed at most times.

With large continuous kilns wickets of some size are necessary for setting and drawing. Attention to the bricking up and luting of these during firing will do much to prevent ingress of unnecessary air. Where hob-mouthed fireholes are fitted the closing quarry should fit well. As the fires burn down the firedoors and regulators require closing to prevent masses of cold air rushing in over the fire bed.

Automatic stoking, where practicable, gives much better firing conditions, since the fire bed is left at fairly constant level.

### Use of a Draught Gauge

Finally the use of a simple draught gauge may help considerably in reducing heat losses by excess air. It is evident that it may not prove practicable to stop all leaks, and the greater the draught the more air will penetrate through them. Consequently use of excessive draught is to be avoided and a simple water gauge will be a useful aid in standardising firing conditions. A water gauge can be made by bending a $\frac{1}{8}$ in. to $\frac{1}{4}$ in. bore glass tube into the form of a letter U and connecting one end to a tube leading into the flue. The tube is then partly filled with coloured water. Having established the water gauge draught reading to give the most economical firing conditions the fireman should attempt to keep his damper settings so as to maintain this in subsequent firings.

Fuller details are given in the the Ministry of Fuel and Power Fuel Efficiency Bulletins Nos. 10 and 27, and these and other similar bulletins should be consulted for many useful suggestions for reducing heat losses in general apart from the special aspect of excess air which has been considered here.

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**Fire at Clay Industries Ltd.**—An outbreak of fire at the Ferguslie, Paisley works of Associated Clay Industries Ltd. on 6th May was prevented from spreading to other parts of the plant. After five hours of work the blaze was controlled and confined to an external store. Damage is estimated to be around £1,000.

# CERMETS

***Demand for Engineering Material to Withstand High Temperatures***

IN a note published in the *Evening Sentinel*, Hanley, Dr. A. E. Dodd, a member of the staff of the British Ceramic Research Association, writes: The newly-coined word "cermets" combines parts of the words "ceramics" and "metals" to denote that cermets are themselves hybrids of these two types of material. For certain purposes, neither metals nor ceramics have ideal properties; at high temperatures metals oxidise and lose their strength, whereas ceramic bodies though free from this defect, do not resist sudden changes in temperature very well. Metals are usually malleable whereas ceramics are brittle; cermets are less malleable than metals, but much less brittle than ceramics.

**The First Attempt**

It would seem that the first attempt to produce such a hybrid material was made about 20 years ago, metallic silicon being added to a clay body to help to improve its resistance to sudden heating and cooling. Since then, research has proceeded from both the metallurgical end and the ceramic end of the possible series of mixtures.

In the materials developed in powder metallurgy, the metal components naturally preponderate. Tungsten-filaments for light bulbs contain metal oxides to inhibit crystal growth. In the hard metal industry in the manufacture of certain sintered steels, permanent magnets, porous iron friction bearings, etc., where the fineness of grain is an advantage, oxides, such as those of aluminium and iron, are added. Larger additions of alumina and silica are made in the manufacture of iron cores for high frequency coils. To avoid sticking to the mould 15 per cent. alumina is added to the iron powder in the manufacture of the containers for the sintering and ignition of certain metals—for example, sintered aluminium nitride magnets.

The ceramic industry produces important materials where the properties of metals (high thermal and electrical conductivity and high tensile strength) and the properties of ceramic materials (low density, scale resistance, and stability) are combined.

The metals can be added to the ceramic material in various ways. Metallic salts can be mixed with the plastic ceramic material and the product then fired, molten metal can be made to penetrate the pre-fired ware, or ceramic and metal powders can be mixed, pressed and then fired.

In the presence of noble metals (for example, platinum), the products can be fired in air, otherwise a reducing atmosphere is necessary. The application of such bodies includes: thermal shock resistant materials with 5-20 per cent. iron in kitchenware; grinding materials with 20-40 per cent. iron, corrosion - resistant materials, etc.; materials for electric resistances and heating filaments; semi-conductors, where the temperature coefficient of the resistance is zero; and condensers, etc., can be made when the ceramic and metallic components are variously combined.

With the advent of the gas turbine and jet engine, there has been a demand for an engineering material that can be used at high temperatures. A great deal of research has been going on since the war on the development of a cermet that will meet the stringent specifications for such a material.

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AT the British Instruments Exhibition at Olympia on 4-14th July, Elliott Brothers (London) Ltd., Century Works, London, S.E.13, will be exhibiting indicating instruments, recording instruments, speed indicating and recording equipment, electrical laboratory equipment and K.V.A. alarm frequency meters and high voltage detectors.

In addition there will be shown remote indication and control equipment, magnetic amplifiers and electronic equipment together with apparatus for process control.

# THE INDUSTRIALIST IN SOCIAL EVOLUTION

*by*

C. BAILEY
Director, Doulton & Co. Ltd.

AT a meeting of the British Pottery Managers' and Officials' Association held at the North Staffordshire Technical College recently with Mr. A. E. Hewitt, managing director, W. T. Copeland and Sons, in the chair, Mr. Cuthbert Bailey prefaced his lecture by a résumé of the evolution of society and summarised his conclusions as follows:

1. That, although enterprise, initiative and ambition are desirable motives, their individual assertion must be subordinated to the greater interests of the general community.
2. That the central feature in human history is the part played by all that comes under the heading of religion whereby that subordination alone has been effected.
3. That it is this cosmic process which is everywhere triumphant in human history. There has been no suspension of it. There has been no enduring tendency towards suspension. On the contrary throughout the period during which the human race has existed, the peoples amongst whom this process has operated under most favourable conditions have been the most contented and the most stable and successful.

He then continued:

**Revolution in Human History**

Taking these considerations into account we shall probably not be able to do better than to follow the lead of Karl Marx in classing England as the best country in which to study the developments of this progressive spirit—this intuitive direction which influences the average man to keep things running smoothly for the benefit of the whole.

The development that is slowly and silently taking place, not only in political parties of all colour, but equally so in great industrial organisations, has, during the last few generations, added to the statute-book a list of progressive measures that constitute in effect one of the greatest revolutions in human history. And, in like manner, there has been a long list of measures aimed at the curtailment and abolition of class privileges. These advances, moreover, have not mainly been the result of coercion, or to obtain political party advantages, but have had their seat in the progressive development that altruistic feelings have attained among us—and not least among industrialists—and in the deepening and mellowing of character which has accompanied the change. It is these feelings that have found a vehicle for expression in that body of public opinion which, moving slowly in the past but more quickly in our own time, has brought about the gradual political, educational and social emancipation of the individual from the dominance of the privileged classes.

The public conscience, which is moving fast in these matters, has all the appearance of being destined to move far.

**Clearly Defined Movement**

I am not now dealing with mere abstract and co-incidental theories but with a clearly-defined movement in politics and industry appealing to the deepest instincts of a large proportion of the ruling classes, and those in-

stincts provide a programme likely in the future to stand more and more on its own merits in opposition to all other programmes whatsoever.

But, let us ever remember that underneath all progressive and humanitarian ideals, there looms the problem of population and its mass livelihood. Progress so far in life has always been necessarily associated with the inexorable natural laws over which man has little control, and over which he can never hope to attain full control, and which render selection necessary. For from the beginning progress has been the result of strenuous and imperative conditions of rivalry and selection. Even if we imagined these competitive forces suspended for a time as between the members of a selected community, that society as a whole must, sooner or later, come into active competition with other societies, and so succumb, or begin once more one of the phases through which human society has already often passed. The conditions of selection being suspended, such a people could not in any case avoid progressive degeneration even if we could imagine them escaping more dire and direct consequences. In ordinary circumstances they would indubitably receive short shrift when confronted with the vigorous life of societies where, other things being equal, selection and the stress and rivalry of existence were still continued.

**Full Utilisation of Powers**

The enormous pressure exercised by the competitive system at its best operates continually to ensure the most economic and efficient system of production. In such a system the best men tend to find the places for which they are best fitted; with the resultant full utilisation of the powers of such men in the direction of invention, discovery and improvement. These are considerations which I believe will weigh, at first cripplingly and finally disastrously, against a socialist or a distributist, or a Utopian community when matched in the general competition of life against communities where the stress of life is greater.

We are concerned not with imaginary beings, but with man as he exists, a creature standing with countless æons of this competition behind him: every quality of mind in the material since the product of this rivalry, with its meaning and allotted place therein, and capable of finding its fullest and fittest employment only in its natural conditions.

But, although these are arguments that have never been seriously dealt with by socialist writers, they are the mere commonplaces which only bring us to the crux of the subject. Impressive as such considerations may be to those who have caught the import of the evolutionary science of the time, no greater mistake could be made than to think that they form any effective answer to the arguments of those who would lead us to socialism or communism.

**The Dominant Factor**

According to these conceptions and creeds the dominant factor in the evolution through which we are passing is the economic one—the era in which we are living being dominated by the rise of capitalism. To understand what capitalism is we have to get behind the superficial phrases and the errors of the political economists of the old school. According to Marx it is a system by which the capitalist is enabled to appropriate the *surplus value* of the work of the labourers, these being able to retain as wages only what represents the average subsistence necessary for themselves and their children in order to maintain this supply of labour. There is thus represented an inherent antagonism between the two classes—at the one pole the continued appropriation and accumulation of surplus value, with the ever-increasing wealth and power of those in whose hands it is concentrated; at the other end we have presented by Marx the progressive enslavement and degradation of the exploited classes. This state of things, he declared, at length will become intolerable; there will be anarchy in industry, accompanied by ever-increasing commercial crises. Then, the incapacity of the capitalist classes to manage the productive forces being manifest, public opinion at last will come to a head; the organised workers will seize possession of the means of production, transform them into public property and socialist production will then become possible. Thus, and thus only,

he claimed, will be accomplished "the ascent of man from the kingdom of slavery to the kingdom of freedom."

It is a conception, whatever its shortcomings, of power and originality—displaying, despite its errors, a profound knowledge of social forces and a grasp of some of the principles underlying our complex modern life. It takes no account, however, of those prime evolutionary forces which lie behind the whole process of our social development.

**Nothing New**

Now, the first fact to keep clearly before the mind in dealing with this theory of society is that this relationship of capital to labour which Marx and socialists generally have described, is nothing more than the expression of a social relationship which has existed throughout the greater part of human history. There is nothing new or special about the fact which underlies the theory of surplus values; nor is it peculiar to the capitalist era any more than to any other era. It depends upon the intellect, enterprise, risk-taking, and the exercise of good judgment on the part of individuals.

But if the phenomenon which underlies what has been called "the exploitation of labour" is in no way new or special to our time, then what is the special factor in modern life which enabled Marx to anticipate the growing power of the workers, and as a result to picture a stage at which it would become irresistible, and at which they would proceed to seize and socialise the means of production? His followers may reply that it is the inherent tendency of the process of economic evolution actually in progress. Yet it is nothing of the kind. The economic problem *per se* has no inherent tendency whatever which it did not possess under any other phase of society and from the beginning. The new factor in the problem is one altogether outside and independent of the economic situation.

**Equality of Political Power**

If we look round at the position of the workers at the present day, and note their relations to the state and to the capitalist class, it will be seen that the one absolutely new and special feature which distinguishes these relationships now, as compared with all past periods, is that the so-called exploited classes, as the result of an evolution long in process, and continuing with increasing pace, has been admitted to the exercise of political power on a footing of actual equality with those who have hitherto held them in subjection. This evolution has its causes exclusively in that ethical development, the course of which has been traced in my previous pages. It is the cardinal and essential feature of the situation dominating the entire outlook and entirely independent of the economic question.

It will help materially towards the clear understanding of the position if this feature of the situation is kept well in view. We may perceive the importance of the factor at once if it is taken away. For if we are to have only the frank selfishness of the exploiting classes on the one side and the equally materialistic selfishness of the so-called exploited classes on the other, then the inherent tendency of modern society leading ever to the subordination of the selfish interests of the individual for the greater good of society as a whole immediately disappears.

**Feature of Our Times**

If a hundred or even fifty years ago there had been nothing but materialistic selfishness on the one side leagued against equally materialistic selfishness on the other, then the ruling power-holding classes, when still immeasurably the stronger, would have been quite capable of taking care of themselves. Instead of enfranchising, educating and raising the lower masses of the people (as they have progressively done at the dictates of an altruistic and intuitive direction which Marx failed wholly to take into account), they would have known perfectly well, as they have always known in the past, how "to keep people in their places," i.e. in ignorance, and in political and economic disability.

But the feature of our times, which there is no gainsaying, is the humanitarian tendency in precisely the contrary direction.

The development that will fill the history of the 20th century will be the profound change in the relations of

capital, industry, labour and the State. The inherent tendency of this progress has been to bring all the hitherto suppressed classes into the rivalry of life on terms of equal social opportunity. While its special significance has consisted in its tendency also to raise this rivalry to the highest level of productive efficiency it has ever reached.

The *political* enfranchisement of the masses is accomplished; the process which now occupies the present period is that of their social enfranchisement.

**Aim of Socialism**

The avowed aim of socialism is to suspend all rivalry and competition in life which not only is now, but has been from the beginning of social evolution, the fundamental impetus behind all progress. The inherent tendency of the wide social evolution now taking place is to raise this rivalry to the highest degree of efficiency as a condition of progress, by bringing all the people into it on a footing of equality, by allowing—nay encouraging — the freest possible play of all forces within the community, and by providing the widest possible opportunities for the development of every individual's faculties and personality.

There can be no doubt that one of the most marked features of our times is the development of the feelings that, classed together under the head of altruistic, represent in the abstract that growing willingness to sacrifice individual welfare in the cause of the welfare of others. This is to be marked in particular by the sensitiveness of the public mind among the advanced peoples to wrong and suffering of any kind. We have become not only increasingly sensitive to physical suffering, whether animal or human, but to the mental suffering which the moral or physical degredation of our fellows implies.

**The Other Side**

But what of the other side, that section of society from which the concessions are being obtained—concessions tending ever to strengthen and equip the weaker against the wealthier of the community?

It must be borne in mind that this section is the present-day representative of the class which for long ages held the people in subjection, which throughout past history consistently reserved in its own hands all power and influence, so as to render any assault on its position well-nigh hopeless. Nay, more, that section which still possesses a reserve of strength which renders it inherently stronger than the other. Yet, by a long list of legislative measures, we now behold the same section educating, enfranchising, and equipping its opponent in the struggle against life. The record of public life for the past fifty years is an astounding spectacle in this respect, and it is only over-familiarity with the disruptive currents of thought in our time which could lead us to forget, or critics to overlook, that the movement we are witnessing is one which is quite unique in the history of the world.

**Roots of this Work**

And the more closely we examine the causes at work in producing this result we shall find that they all have their root in the phenomenon we have been considering. It will be observed that the factor of most significance is the extent to which this deepening and mellowing of character and understanding has progressed among the power-holding class.

As light continues to be let in on the foundations of our social system the forces of development do their work silently and effectively. The best and most generous minds are impressed and affected. The effect produced on them is such that, instead of siding with the class to which by tradition and individual interest they belong, they take their places on certain issues in the ranks of the opponents. And those who remain temporarily on one side are thereby hardly less affected.

And so our modern progress towards the equalisation of opportunity continues to be made. It is not so much the determination of the attack; it is rather that, through the all-pervading influence of our civilisation, and of the immense and accumulating fund of altruism with which it has slowly been equipped, the occupying section of society is intuitively directed to maintain the social evolution

developing smoothly, and for the benefit of the whole community.

**Capitalism**

Let us now consider the economic and social system that is termed "Capitalism." Capitalism is the law of individualism, offering the combination of incentive with its reward, and is the system which underlies most of human ambitions and activities.

I claim, further, that it is also much more than that; that it is a national policy founded on a national interest. It is a system which ensures that commerce, to retain its strength and power to provide the nation's life, must be on an organised basis which develops the clearest insight into how indispensably one industry hangs upon another, and has the clearest concept of how essential it is that ability and genius should have their scope.

I believe that under capitalism alone can the alchemy of genius best transmute all things to its own element: make a statesman of a blacksmith's apprentice, an industrial magnate from an imaginative labourer, and an industry out of a backyard experiment. We in Britain inherit a great tradition of national policy, and it is well to remember that in industry as in war it requires a master-mind to lay down the strategy of a campaign.

**Personal Interest**

A clerical friend of mine who dislikes my material views suggests that none fought in the Great Wars for selfish interest, whereas millions died for an ideal and for patriotism. It is a plausible point, and yet let us remember that both wars in themselves were a great national emotion which was the reaction against injuries to the national interest, and it remains true that while men upon a great occasion are willing to fight and to die for patriotism they live and work as a general rule for personal interest. It is a motive which never sleeps and never dies, but operates silently and steadily behind all the pretexts and pretensions of human action.

I suggest that no statesman and no cleric has the right to assume that human nature and the nature of nations—which have remained constant since history began—will change fundamentally in his day and generation. I venture to think that if he so presumes he will end by betraying his trust and his charges, and that the only safe teaching is a national policy founded upon national interests, and not solely upon morality and metaphysics.

**More than Material Aims**

Capitalism, like all systems is capable of monstrous abuse, and by ruthlessness and selfishness some have acquired great wealth. As in every human interest it is betrayed by what is false within; but it is my submission that the average industrialist strives not so much for power, but for something much better than power—security and harmony, and a life alert to the deep-rooted economic causes which work for change and evolution under the surface, and which so vitally affect the security of all. Modern commercial policy does profess to have more than mere material aims. Even the cynic recognises that humanitarianism, harmony and security march together; for humanitarianism even if given in the immediate interests is generally maintained in the general and enduring interests.

But, it is often asked, how can modern industrialism under the capitalist system, with its recurrent reorganisation and re-equipment, be justified if it throws men on the scrap-heap? And how many of those so used are to be replaced by machinery, and what will happen to them?

In such difficulties, in which thousands of workers and their families may be placed any year, it is not surprising that emotion and sentiment should sway the judgment of all who are capable of deep feeling.

The conception of capitalistic ruthlessness will be preached, and be dominant in many minds.

But a contest with such evolution is to tilt against windmills, and for these reasons.

The standard of life which workers may maintain is not indicated solely by the fixed daily or piece-rate to which they are entitled, but mainly by the number of days per week they are employed month in and month out. And what may be emphatically asserted is that if re-organisation and re-equipment is not periodically

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carried out efficiently and comprehensively the standard of life of the masses will dwindle rapidly, and to a level much lower than that which prevails today?

**Painful Choice**

There appears to me no escape from this painful choice—one must either recognise as inevitable the temporary suffering of a proportion of workers and their families who are dependent on the industries urgently in need of re-organisation, or reconcile oneself to the speedy and progressive loss of trade and opportunity of mass employment to those countries which are more alive to developing opportunities.

Can it be contended that, whatever occasional (and in most cases temporary) hardship and disadvantage to individuals may follow from reorganisation, that it will lie more heavily and seriously than the definite continuance of conditions as they now exist—and the ever deepening destitution of the mass of people completely dependent on the industries which must re-organise if they are to survive in competition with reconstructed industries abroad?

In no circumstances of human difficulty is it more imperatively necessary that decisions and public appreciation should be based on reason, and on a realistic relation of all the factors which constitute the whole economic life of a nation.

**Industrially Organised**

Today all civilised countries are organised industrially and on the alert to snatch and harness every piece of borrowed knowledge of scientific discovery; and what is to be ever remembered is that every British industry operates under the influence of world competition, and that all industries are compelled continuously to adjust themselves to new levels. To adopt the principle of refusing to be associated with reconstruction except under an entirely new industrial system, or to refrain from influencing the operation of the reconstruction process, would be to play into the hands of our competitors abroad and would inevitably result in lower wages and a reduction of the general

standard of livelihood in the country.

But though it is my submission that such industrial surgical operations are necessary and essential, and stand as an imperative duty on industrialists to whom the vast majority of workers look for steady employment, I, for one, accept wholly that such operations should not be performed without a sufficient anæsthetic—maintenance, and, in cases of permanent replacement, instruction of the replaced so that they may have a chance of new occupations.

**Democracy—The Testing Point**

Democracy has indeed reached the testing point, and therefore sane and experienced men deplore generalisations respecting conditions and standard of outlook and of conduct presented with a balance of emphasis which can hardly be other than misleading. The stability and prosperity of this country are inseparably linked with its industries; on them alone can the multitude depend to escape destitution. Today they stand or fall on the successful establishment of a basis of reciprocal trust and confidence. And it is the task of every true patriot to contribute to that establishment. For this present generation faces the grim task of defending society and its traditions against attacks from without and corrosion from within.

I believe that those who attribute the world crises solely to German and Soviet attempts at world domination are guilty of over-simplification, and are confusing immediate happenings with fundamental causes. This limited view is dangerous since it leads those who adopt it to assume that the main task of nations and humanity is to keep Germany and Russia in check, and that, providing this task is effectively fulfilled, the challenge to peace and democracy is removed. This theory may well be disproved by the experience of the coming years, and we may be made to realise that mankind has entered an era of acute unsettlement, and that war has been no more than a prelude to that ordeal.

Those who think less superficially, and who are conscious that something more profound has been happening to mankind than a conflict of the traditional type, will ask themselves what are the elements in our civilisation which may cause decay and bring about the danger of collapse. And in the process of their analysis they will appreciate that the outstanding feature of our society is that it has been based on the design of endowing a minority of individuals with the ownership of the sources of wealth, of raw materials, the machinery which translates these raw materials into saleable goods, and the financial organisation which controls the distribution and purchase of these goods. This social order has carried with it certain inevitable consequences. It has divided mankind into a class of owners, and a class which has been dependent upon employment by the owners.

I cannot here follow this enormous concentration of economic power, its building up of politico-economic spheres of influence, and the tendency of combine-owners to establish cartels and control groups; or how this enormous concentration of economic power into entrenched interests has necessitated the development of the modern competitive State. This direction of our civilisation towards the building up of economic and political spheres of influence resulted in a network of separate nationalisms, at war economically with each other in their struggle to secure as large a portion as possible of the world market. And the tendency of the combine-owners to establish cartels, and collaborate internationally in their own material interests, has not averted the clash of those rival nationalisms; it has resulted in outbursts of military war, and finally, their own destruction.

**At the Junction**

The lesson appears to be that a civilisation constructed on a class basis cannot be stable once the majority class—having already been conceded political power—has become dissatisfied with it, and persuaded that such an order is unnecessary. So we stand at a junction of the roads. If we are to advance to a stage in our social development, where there is a reasonable prospect of outlawing war, of raising the general standard of living and of human content, and of providing steady employment, the next stage must be equalitarian in character. We must create this new

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order realising that it constitutes a revolution in cultural, humanitarian, political and moral thought as well as in the political and economic spheres.

We cannot guarantee our future. But at least we—especially we in industry—may be forewarned that, if we refuse to understand this formidable responsibility, we may be condemning our children to a fate even more grievous than any which we ourselves have endured.

Gentlemen, the fundamental principles governing human conduct are extremely simple principles. And, happily, individual conduct can communicate the conviction that there exist certain absolutes of right and wrong, and that justice between man and man admits of no camouflage or escape. To the very depth of their being men of goodwill must become men of peace, justice and goodfellowship; for them strife being the most squalid of human calamities, offering no profit, honour or reward. The clash of sectional interests occasioned by narrow or selfish views, is an inexcusable obstruction to national concord, which can only be achieved by the growth of common instincts for right, justice and harmony. These are the things that alone make for humanity and civilisation. The future of British industry possibly depends on the purge of old doubts and distrusts more than any other factor.

I believe there is a true context within which industrial events during the last 100 years have tended to develop, and that context I have endeavoured to present for your reflection upon it.

I am here to deny that industrialists wish to obstruct social reform. On the contrary, there is desire on their part steadily to extend such reform providing due regard be preserved to the great danger of mortgaging the future. No responsible reformer desires a breakdown. On the contrary he dreads it, for it would compromise the achievement of the cause to which he devotes his life. And it is the essence of the progressive adjustment in the general standard of living, which I illustrate in this paper, that the demands should be limited to a rhythm which industry and society can support without breakdown.

Thus, no responsible reformers should attempt a wage rate that would go beyond the framework of the existing international economic order, and so lead to unemployment.

In this vital hour there seems to me to be only one choice and it can be summed up in one word—co-partnership; a co-partnership in fact and in spirit, and based on a wide realisation that the interests of employers and employed are inseparably linked together for good or ill. The value of co-operation of the workers throughout British industry, once they are convinced that the success of a factory is as much their concern as that of the management and the shareholders, would enable them to distinguish between what is gold and what is brass; what is realism not illusion; and what is practical, not mere wishful thinking. To pretend that industrial stability and strength can be secured by any other means would bring the disaster which all men of sense and goodwill seek to avoid.

The great gamble of our time appears to be whether the comradeship of true democracy or Communist tyranny will control our industrial and social lives; and the real menace lies in social injustice from one section of society, and the unscrupulous propaganda from the other.

If this interpretation of the world upheaval of the last 40 years is in any sense correct, then the predominating difficulty is to help those who believe in Christian principles to understand better to how great a problem and conflict they are summoned by the needs of our time; and also to cause those, who as yet do not believe, to ask whether there is anything else except Christian Faith that can in the last resort be the champion of human dignity, security and happiness.

## STOKE AND HANLEY BRANCH

THE May meeting was held in Hanley Town Hall on Monday, 21st May. The meeting, which was well attended, was under the chairmanship of Mr. E. T. Mayer, and amongst those present was Mr. H. Hulse, the Association president.

Mr. F. Timmins, the general secretary, presented the minutes of the last meeting of the Executive Committee and reported that a special committee had been formed, and was now at work, to investigate the rules governing eligibility for membership of the Association, and to review that part of the Association's Rules dealing with qualifications and similar matters.

The chairman reported that one of the winning papers entered for the Association's annual prize, would be read by its author at the next branch meeting. The paper deals with production control.

After the completion of the branch business, Mr. I. R. Forse (W. T. Copeland and Sons Ltd.) gave a talk on management, which was followed by a period of questions from members. The talk entitled, "So You Want to be a Manager," will be published in July 1951, issue of CERAMICS.

A vote of thanks to the speaker was proposed by Mr. S. Glover and seconded by Mr. E. Evans.

## BIRLEC LIMITED

WE have received two leaflets describing the Birlec Lectrodryers, from Birlec Ltd., Birlec Works, Tyburn Road, Birmingham 24. The plant is used to remove troubles caused by corrosion, clogging and general contamination resulting directly from moisture in the atmosphere. The removal of moisture from air, gas and organic liquids, as well as the control of humidity in workrooms and stores are some of the uses of the plant. The Lectrodryers contain a solid granular absorbent material which absorbs moisture. The moisture so retained is released by heating after which the drying process can be repeated.

Leaflets describing typical uses of the Lectrodryers, specification details and broad working data are also available.

# Photometric Determination of Alkalis in Portland Cement

Our American Correspondent

THE content of sodium and potassium oxides in Portland cement sets an important limitation on its use for many applications. For example, where the cement is to be combined with crushed rock or gravel to make concrete, the alkalis may sometimes react with soluble silica present in the aggregates. This causes expansion of the concrete, resulting in the formation of cracks and weakening of the structure.

## Flame Photometry

While it is highly necessary that the alkali oxides in Portland cement and cement raw materials be accurately determined, the usual gravimetric procedures for doing this are very time-consuming and require the services of specially trained technicians. Seeking a more convenient and practicable analytical procedure, W. R. Eubank and R. H. Bogue of the U.S. National Bureau of Standards recently completed an extensive study of the method of flame photometry. Their results indicate that this technique holds considerable promise for the rapid and accurate determination of alkalis in Portland cement. The method has now been adopted by the U.S. Federal Specifications Board as an Alternate Standard, and by the American Society for Testing Materials as a Tentative Standard, for the determination of $Na_2O$ and $K_2O$ in Portland cement.

## Procedure

In the method of flame photometry, the solution to be analysed is atomised into a flame. Light characteristic of each element to be determined is then isolated, and its intensity is measured. In this way the principles of analytical spectroscopy are applied under conditions that allow rapid determinations to be made with relatively simple apparatus by personnel having only moderate training.

In the Bureau's investigation, a group of five cements was subjected to repeated analysis for $Na_2O$ and $K_2O$ by means of the flame photometer over a period of several weeks. The results, expressed as percentages of $Na_2O$ and $K_2O$, were highly consistent. The standard deviation varied from 0·005-0·017 for $Na_2O$ and from 0·000-0·023 for $K_2O$. The maximum spread for any cement was 0·05 per cent. for $Na_2O$ and 0·06 per cent. for $K_2O$.

To evaluate the personal factor in these determinations, the flame-photometric results obtained on a series of cements by three operators using two different units of the instrument were compared. The average maximum variation from operator to operator was only 0·03 per cent. for $Na_2O$ and 0·04 per cent. for $K_2O$, indicating that the personal factor in operating the flame photometer is small and that a highly trained operator is not necessary.

## Standard Solutions

Use of the flame photometer in this work requires standard solutions of known alkali concentration, which provide the basis of reference in each determination. These solutions must be so constituted that the excitation conditions they produce in the flame are similar to those produced by the solutions to be analysed. The ideal standard solution would thus be composed of the same elements in about the same

concentrations as the cement solutions to be analysed. Such standard solutions could be approximated by the addition of definite amounts of sodium and potassium chlorides to a cement solution of known but low alkali content. However, there are serious objections to the use of a cement for making up the standard solutions. In the first place, cements containing less than 0·1 per cent. of both $Na_2O$ and $K_2O$ are not commonly available. Furthermore, any error in the content of those oxides as determined gravimetrically would be reflected in all subsequent photometric determinations. Also, if lithium oxide is present, it will introduce an error in the gravimetric value for $Na_2O$, which as commonly determined, includes any $Li_2O$ that is present.

A series of standard solutions was therefore prepared containing calcium ion and hydrochloric acid in approximately the same concentration as would occur in the solutions of Portland cement to be analysed. When these standard solutions were used, the values for $Na_2O$ and $K_2O$ obtained with the flame photometer were in excellent agreement with those obtained by gravimetric analysis. The Bureau is therefore recommending the CaO-HCL solutions as standards in the flame photometric determination of alkalis in Portland cement.

**Propane Near Ideal Gas**

An important consideration in using the flame photometer is the gas employed for producing the flame. This gas must be of constant composition and pressure and free of materials that may interfere with the spectral emission. For alkali determination it should also provide a flame temperature that will readily excite the alkali elements without affecting other elements that require higher temperatures for excitation. At the Bureau propane was found to be nearly ideal for exciting the alkali elements with a minimum of interference from other causes.

The flame photometer in use at the U.S. National Bureau of Standards

(continued on page 208.)

# Lowered Status of Technological Education

## *Comment on the Weeks' Report*

*by*

W. F. COXON, M.Sc., Ph.D., F.R.I.C., F.I.M.
(EDITOR OF "CERAMICS")

THE future of technological education has been the subject of more reports, findings and committees than practically any other aspect of the Social Services. They include the Percy Report, the Report of the City and Guilds of London Institute, the Barlow Report, the Report of the Parliamentary and Scientific Committee, the second Report of the Advisory Council on Scientific Policy, the Report of the Institute of Physics, the Reports of the Institute of Electrical Engineers, the Report of the Federation of British Industries, a publication by Political and Economic Planning and a Conference under the title "Industry and the Universities" organised by the Federation of British Industries.

### Referred to Committee

Yet when the question of technical education was being discussed 100 years ago individuals formed influential groups which brought positive action. By comparison the present-day attitude is one of continually referring action or responsibility to a committee often reaching unwieldy proportions. The most recent report entitled "The Future Development of Higher Technological Education" issued by the Ministry of Education on behalf of the National Advisory Council on Education for Industry and Commerce is the ebullition of a committee consisting of no less than seventy-three members.

### Background to Technical Education

Let us go back quickly to the growth of technical education in Britain. The same finding of Zenophon, "There is a social stigma attached to the mechanical arts which are rightly dishonoured in our cities," was much to the fore in the universities at the beginning of the 19th century. Yet industrialists, facing the culmination of an industrial revolution, realised that neither the academic education system of schools nor that of the universities faced up to the problems of industrial production. The science laboratory in our great public schools was a curiosity until only about forty years ago. The educationalists accepted their formalised ideas on education, and there was an undue emphasis upon the classics. The older universities were shockingly reactionary. It was 1871 before Oxford admitted noncomformists, drawn mostly from the industrial areas, to the B.A. and M.A. degrees. It was 1877 before they granted revenue for science studies. It was 1920 before they admitted women as full members of the University, and in 1927 they limited by statute the number of women to one-quarter of the total strength. At Oxford a degree in science was not awarded until 1895.

The University of Cambridge was likewise. It admitted nonconformists in 1858; they admitted women to degrees in 1923, but not as full members of the academic body. They granted an M.Sc. degree in 1920.

It will be thus apparent that the place of science in the older universities has been forced on them by sheer expediency because of the pioneering success of the University of London, which was slowly and relentlessly drawing those whom wished to study science away from the older universities.

**Growth from 1800**

Consider the growth of technical education from 1800. First there was the Mechanics' Institute—Birkbeck College, 1824—and by 1841 the number of similar institutes was more than 200 and by 1860 more than 750, mostly in Lancashire, Yorkshire and the Midlands. In 1878 was formed the City and Guilds of London Institute, with funds provided by the City Livery Companies. The famous London Polytechnics came along in 1883.

Yet it was not until 1889 that the Technical Instruction Act enabled Local Educational Authorities to support technical education, and in 1891 the Local Taxation (Customs and Excise) Act, commonly called "whisky money," provided the first State funds for technical education.

From 1889 for the next ten years many technical schools were built, particularly in the industrial areas, but the Education Act of 1902 can be considered as having definitely slowed down developments in facilities for technical education.

That Act put the provision of secondary and to some extent university education as the responsibility of the Local Educational Authorities. It was here that one began to witness the first impression of the older universities upon the State system of education. By that time even the study of "pure" science was considered as somewhat more sordid than classics, and indeed a "classical" education was thrust on to the State educational system largely through the influence of the older universities.

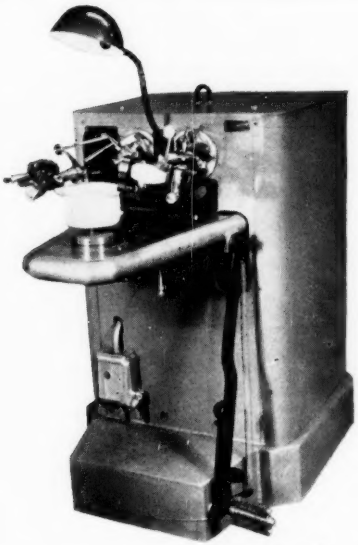
The latter have maintained this stranglehold continuously, and it was only when the 1914-18 war showed up by comparison the poor scientific training of the Briton compared with the German that State Secondary Schools, and the well-known public schools began to take an interest in a scientific curriculum. Yet even here their interest was based on philosophy with an academic bias as witnessed by the university faculties in "pure" science as opposed to "applied" science. By comparison Germany had set out to build an industrial nation by systematic training in technology throughout all grades from workers to leaders.

Thus, as from 1902 technical education in Britain was squeezed by two millstones. Firstly the necessity for the local authorities to take financial responsibility for secondary school and university training which was a financial squeeze, and secondly by the social stigma attached to the mechanical arts which is directly attributable to the influence of the older universities.

It is in this light that the universities must be examined.

**University of London**

Against the reaction to science and applied science by the older universities let us examine the attitude of the University of London. Its Royal Charter was granted in 1836. By 1858 its degree examinations were thrown open to anyone from the British Isles and the Empire. By 1878 it had admitted women to the degree examinations and was thus the first university in the kingdom to do so. In 1859 it formed a faculty of science and was thus also the first university in the country to take this step.



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Simultaneously there sprang up some famous Technical Colleges throughout the country—Birmingham, Bradford, Manchester and North Staffordshire are classic examples.

However, with the turn of the 19th century came the growth of the provincial university, and to a greater or lesser extent these were modelled on the mediaeval tradition still prevailing at Oxford and Cambridge. One or two showed foresight by the granting of degrees in applied science — Leeds, Sheffield and Manchester are examples.

And so today there is no doubt that the possession of a university degree which has been open to anyone who cared to study, for nearly 100 years, through London University has become traditionally something of importance. Until fifty years ago the prestige value of a degree in science from the University of London far and away exceeded that of any other university, and that was the case whether the degree was obtained externally through many of the fine Technical Colleges in the country or through one of the internal colleges of the University of London. Whilst London was thus pioneering the field of technical and scientific education within the orbit of the university closely allied with the practice of the Technical College, which were in many cases drawing part-time students from industry, the newer provincial universities were unfounded and the older universities had not trod, even in theory, the oily floors of wealth production.

It is important, therefore, in approaching this question of technological education to get the background clearly in perspective, for there are three premises upon which any study of this subject must be based.

1. The older universities have

always proved themselves reactionary, firstly to the study of science, and secondly showed an abhorrence of "applied" science.

2. The Technical Colleges of Britain, which include many famous names, have been the sole educational connection between theory and practice. In this they were helped by the University of London, which offered facilities for their students to take external degrees.

3. Many of the provincial universities once started as equivalents to university colleges, and again it was the acquisition of the external degree from the University of London which enabled these colleges to grow in status until they were able to obtain a charter of their own.

4. Traditionally the reward for training equivalent in depth of study and equal in length of period to that of the university degree course is indeed a degree.

5. From time to time many attempts have been made to offer an equivalent award in the form of an associateship of this or the other society. For example, the associateship of the Royal Institute of Chemistry is practically equivalent to a B.Sc. degree in chemistry in terms of the initial examination, whilst the practical examination of the former is more exacting than for a degree. Yet, a first- or second-class honours degree in chemistry will grant exemption from the A.R.I.C. examination, but in return an A.R.I.C. does not grant remittance of the B.Sc. examination. It is important to realise, therefore, that the status of an associateship in science and technology does not have the same attraction to the student as a degree in science.

**Analysis of Two Reports**

It is in this knowledge that we must analyse two fairly recent reports on training for technology. Firstly comes one from the Ministry of Education in 1945 under the title "Higher Technological Education," the report of a committee formed by the Coalition Government as a result of the 1944 Education Act. Its terms of reference were clear. "Having regard to the requirements of industry, to consider the needs of higher technological education in England and Wales, and the respective contributions to be made thereto by universities and Technical Colleges and to make recommendations among other things as to the means of maintaining appropriate collaboration between universities and Technical Colleges in this field."

**Committee Membership**

Of a committee of fourteen members, five were intimately associated with the universities, three were directly concerned with industry; there were three representatives of the Technical Colleges, two Directors of Education and the Director of the National Physical Laboratory. Of the industrial representatives two were associated with very large companies, two of which have since been nationalised. The companies were too large to be described as representative of British industry where 80 per cent. of the manufacturing firms employ less than 100 workers and are responsible for something like 75 per cent. of the national output. The point is that the make-up of this committee enabled the universities to be the largest single group.

**Type of Award Offered**

The findings of this committee are already well known with their proposed new "Colleges of Technology." There was obvious disagreement as to the type of award to be offered to the student, and opposition to a degree came obviously from the university group. The chairman tried to soften the blow by a personal note concluding the report, which said: "I wish to put our disagreement (the nature of the award) in its proper perspective.

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It is not a disagreement between the universities' members of the committee and other members . . ." The chairman considered that "The degree of B.Tech. seems to be perfectly appropriate to Colleges of Technology." This, of course, would open itself to M.Tech. and D.Tech., the respective Master and Doctorate university equivalents.

If the universities escaped by agreeing to differ on the Percy Report, they certainly took an ample measure of precaution when it came to the recently published Weeks' Report. The National Advisory Council on Education for Industry and Commerce was set up under the chairmanship of Sir Ronald M. Weeks in 1948 to advise the Minister. It consisted of seventy-two members, fifty-two of whom were appointed by the Minister on the nomination of ten regional Advisory Councils for further education, and twenty directly by the Minister.

**Findings More Definite**

The findings of this committee were very much more definite on the question of an award than the Percy Report. In the Weeks' Report the universities came out into the open, for in it appears this sentence: "It (a degree) would not receive the support of the universities . . . The final recommendation of an award should be an Associateship of the Royal College of Technology as a first level award (equivalent to B.Sc.), Membership as a second award (M.Sc.) and a Fellowship and Honorary Fellowship as the third (D.Sc.)." Baldly, then, the qualification will be A.R.C.T., M.R.C.T. and F.R.C.T. There will be no Doctorates for an engineer.

When one examines the vast number of associateships, member-

ships and fellowships which are granted by a variety of societies, and which can be bought by the local greengrocer for two or three guineas per annum, the prestige handicap to students of the Royal College of Technology will be quite obvious.

We now have a system of State education whereby something like six million boys and girls are in either secondary modern or secondary grammar schools. The university population fluctuates around 80,000-90,000 potential graduates. There is now practically nothing to prevent any boy or girl of ability, irrespective of their parents' income, from proceeding to higher education at the university level. Thus, whether one likes it or not, the new Royal College of Technology is to compete with the universities for recruitments of students of the 17-18 age group. Frankly, the universities have been strong enough in this latter Report to ensure that the prestige value of their degree will enable them still to present the bigger attraction to the bright student. The net result will be obviously that the universities will draw the best of our school students for their degree courses, and the left-overs will be available for the new Royal College of Technology.

**Famous—Not for Technology**

Recently C. R. Morris, vice-chancellor of the University of Leeds, talking on this Weeks' Report on the Third Programme of the B.B.C., said categorically that the universities were famous not for technology—they imparted a good general education based on the humanities. He agreed that the university approach was academic and that applied science was a recent introduction. In short, he reiterated those famous words of Zenophon: "The mechanical arts carry a social stigma and are rightly dishonoured in our cities."

The battle between theory and practice had been won by the theoreticians around this committee table—and the committee, consisting of more than half its members university graduates, voted for withholding the traditional value of a university degree from their new Royal College of Technology. Thus they deliberately placed it in the "second educational division," compared with the universities, at its inception. Naïvely they agreed with this because they suggested that it was up to this "new-born" child to fight for recognition. What the universities failed to appreciate was that technological education in Britain is by no means a new-born babe, and today it is very much alive.

**Weeks' Comment on University of London**

In 1948 there were something like 17,000 students in the technical colleges of Britain undertaking either external or internal work on a part-time or full-time basis for the degree of the University of London.

That is indeed a quarter of our total university population. Whilst the Weeks' Committee was discussing, this training was actually taking place. Yet the splendid pioneer work undertaken by the University of London is damned with faint praise by the Weeks' Committee. It says "The London University external degree, though carrying a considerable prestige, suffers from two defects . . . Its scope is, and is likely to continue to be, limited to a few technologies such as engineering, mining and metallurgy. The external examination does not permit as much freedom and flexibility as are essential if a college is to make its full contribution to technological education."

Why indeed the London University external degree with its close alliance with the Technical Colleges of the country should be limited to a few technologies is in extreme doubt. Why the freedom and flexi-

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bility of the college should not prevail is also in extreme doubt. May the committee be reminded that one of the most eminent chemists in this country, namely Professor F. S. Kipping, pioneer of the silicone resins, Fellow of the Royal Society, taught no one but students for the external London degree all his life at the then University College of Nottingham.

The trouble is that the Technical Colleges by offering university degrees in applied science are striking at the traditional monopoly of academic awards held for centuries by the older universities. If a student could gain a degree through the "Royal College of Technology" under the auspices of one of the well-known Technical Colleges of the country he might be more likely to go there than to the university. The universities have a vested interest in their survival, and they struggle to disguise their personal politics in high-sounding moral phrases so that they may continue to reign supreme.

**In the Melting Pot**

The future of technical education is still in the melting pot. This Weeks' Report threatens in one full swoop to disrupt the collaboration built up between Technical Colleges and various universities such as is the case in Manchester, Durham and London. It threatens to make the Technical Colleges second best in comparison with the universities. It ensures that the universities will get preferential consideration from both teachers and schoolchildren in secondary schools when it comes to future studies. It means to perpetuate the system whereby the greatest number of bright boys pass on to an academic education.

A tremendous battle must be

waged, and the Technical Colleges throughout the country, as well as industrialists, must fully realise the implication of the move in the Weeks' Report. Indeed, both will be worse served than ever before. Already the universities can offer preferential salaries to lecturers by comparison with Technical Colleges which are fixed to the Burnham Scale. Already the universities hold the monopoly of the State grants for higher education in this country.

**"Full Characteristics"**

Surely there is no objection to a Royal College of Technologists catering for the Technical Colleges of the country, but awarding degrees such as B.Tech. or B.Sc.(Tech.), etc., as recommended by Lord Eustace Percy? Yet read the findings of this Weeks' Report. "Some support has been given by one of the regional Advisory Councils and a number of teachers in Technical Colleges to associate all colleges undertaking advanced work in technology within a body to be known as a 'Technical University,' granting degrees and approving and moderating courses of study leading up to such awards. There is, however, the substantial fact that most universities have made it perfectly clear that any attempt to establish a national degree awarding body which did not have the full characteristics of a university would meet with their strong opposition." What these "full characteristics" are is not defined, for every university seems to be different.

There it remains, and it is up to the Technical Colleges, industry and those interested in technology to fight the universities. There is no morality in the argument. It is merely a question of which Institution gets most money from the State coffers, and it appears from the Weeks' Report the universities are winning hands down.

The Weeks' Report is a reactionary document offering little tangible improvement in technology training as far as industrialists are concerned.

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PHOTOMETRIC DETERMINATION OF ALKALIS IN PORTLAND CEMENT—(*continued from page* 200).

The internal-standard procedure, often employed in spectrographic determinations, is sometimes used with the flame photometer. In this method, which employs a dual optical system, the emitted light-intensity ratios of the element sought and of another element introduced in known concentration are measured, rather than the absolute light intensitives of the element sought, as in the direct intensity method. The disturbing effects caused by gas and air pressure fluctuations, the presence of foreign ions and molecules, and viscosity differences are thus minimised. The Bureau therefore made a comparative study of the relative advantages of the two procedures for determination of the alkali elements in Portland cement and cement materials.

In either case the flame photometric results compared favourably with the values obtained by gravimetric analysis. However, the Bureau does not recommend the internal standard method for determination of the alkali oxides in Portland cement.

**Weakness of Method**

The weakness of the method lies in the introduction of a fixed amount of lithium to both the standard and unknown solutions in order to obtain intensity ratios of the alkali elements to the standard. As lithium is unfortunately present in some raw materials that may be used in cement manufacture, the reliability of the internal standard method is thus open to question.

# Automatic Methods in Pottery Manufacture

ADDRESSING the pottery section of the British Ceramic Society recently, Mr. A. Maddock, of John Maddock and Sons Ltd., Burslem, said he believed automatic and semi-automatic making methods were a great stride forward and might eventually turn out to be the salvation of the industry.

They produced precision-made articles, with greater production and less labour. With proper supervision they produced better articles, and they had developed a need for first-class managers and efficient maintenance fitters.

### Trade Unions

"I have heard it claimed that American unions favour mechanisation, while British unions do not," he said. "That certainly is not true of the British Pottery Workers' Union. They knew about automatic and semi-automatic machines before they were put on the market, and they gave the machines their blessing from the start."

Speaking on "The present position of automatic making methods," Mr. Maddock said their progress had been like a fairy tale. Not long ago the boiler man was the engineer on many pottery factories. Now most firms had competent engineers, first-class maintenance fitters and many had modern fitting shops.

### 20 Years' Progress

Dealing with the progress made in the last 20 years and with the difficulties involved in the changeover to mechanisation, Mr. Maddock said factories had first to be modernised, quality had to be improved and variety maintained and increased. He detailed the ways in which this had been achieved in the flat and cup making processes and added the warning that the output of semi-automatic machines should not be speeded up beyond the point recommended by the makers, or quality would be sacrificed. This same warning applied to the process of drying, he said.

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Handle cutting machines had been a great boon to the industry. A few machines cut handles truer than any skilled cutter could, but the skill of the few craftsmen who were still cutting by hand had to be seen to be believed.

Showing slides to illustrate some of his points, Mr. Maddock described new machines that were being used in the drying and flat and cup making processes.

**Slight Modification**

The changeover to modern methods had shown that with a slight modification to the shapes of some articles, easily made ware resulted. If mechanisation had done nothing else it had made manufacturers look carefully into the whole subject of making and the losses incurred in doing so.

Mechanised making had produced precision articles and scientific drying had resulted in the making shops generally being tidier and cleaner. In many cases mould-running had been done away with, and all the changes had resulted in better health and working conditions for the operatives. With modern dryers, the steam or heating factor was shut off when the operatives ceased work and this meant a big reduction in the use of fuel.

It was advisable to retain a certain number of hand jiggers to make small quantity lines.

**Production Figures**

To illustrate the increased production achieved by modern methods, with enhanced quality, Mr. Maddock quoted the following figures: A maker on an automatic cup machine could produce 1,350 dozens of 12 cups in a 44 hr. week, against 900 dozens of 12 made by a cup maker and attendant; a semi-automatic machine maker could produce 1,050 dozens of 12 against 900 dozens of 12 made by a maker on a hand jigger, together with a batter.

**Further Applications**

Modern methods could still be used in a number of other departments without any detrimental effect on quality, he said. These included under-glaze, banding and lining, rubbing on prints and washing off paper, for glaze spraying and handling in warehouses. In the latter connection, Mr. Maddock expressed the opinion that carton packing would soon supersede crates.

The speaker was thanked by Mr. L. Bullin (President) who presided.

(With acknowledgment to the *Evening Sentinel*.)

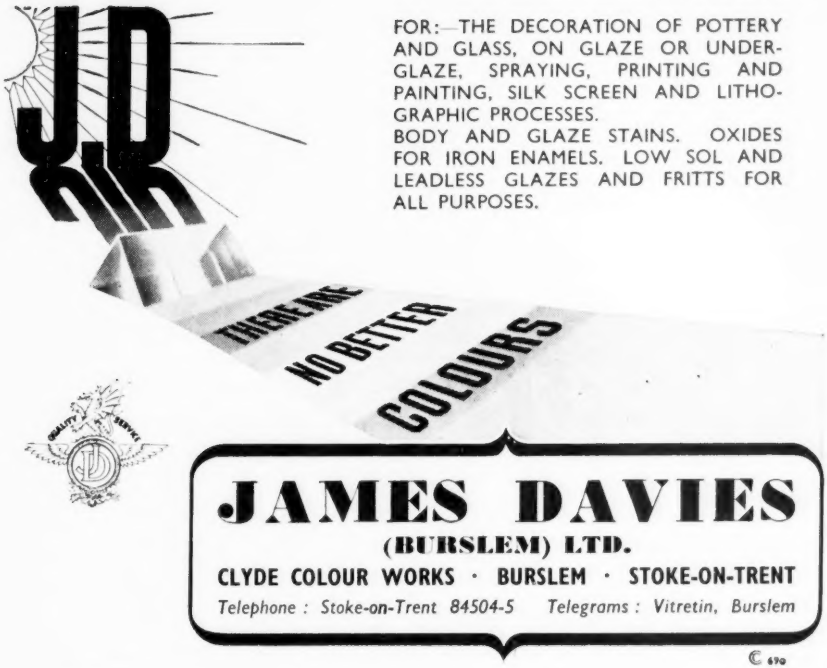
# Standardised Laboratory Glassware

IN a paper printed in a symposium —"Standardisation in the Chemical Field"—by the Royal Institute of Chemistry, Mr. R. H. Powell draws attention to this subject.

**History**

Before the 1914-18 War there was only a small laboratory apparatus manufacturing industry in this country. Most of the apparatus used was imported from Continental sources and serious difficulties were experienced during the war in obtaining sufficient scientific equipment. The position has radically changed since then and, although Great Britain is not completely self-supporting, yet the great bulk of her apparatus requirements can now be supplied from home sources and about £10,000,000 worth of apparatus is exported per annum.

Having in mind, however, the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history of the industry, an examination of the range of its products discloses an irrational state of affairs in regard to shapes and sizes, which are frequently based upon original Continental models; and since there have been added to these models sizes and shapes thought to be peculiar to British needs, a welter of heterogeneous sizes has grown up, few of which bear any rational relation one to the other. There is now, therefore, a pressing need for a fundamental reconsideration of shapes, designs, materials and function of much chemical apparatus, if the laboratory apparatus industry is to be capable of meeting modern needs. Standardisation has become essential if the industry is to increase in efficiency. The attitudes of user and manufacturer towards standardisation are often opposed. Some users have characterised standardisation as "monopolistic regimentation." It is far from the manufacturers' desire to put the user, as it were, into a strait-jacket; but volume output must be increased and diversity reduced if apparatus demands are to be met.

I do not think that the term "apparatus" should, in this connection, include such physical instruments as balances, spectrographs, absorptiometers, polarographs, *p*H meters, etc., but only apparatus of the type exemplified by beakers, flasks, porcelain, lampblown glassware and some metalware.

**Users of Apparatus**

The types of user who would be affected by standardisation can be classified conveniently as follows:

(a) *Technological.* In the main this, the most important type of user on a volume-consumption basis, is interested in apparatus used in routine analyses and in tests prescribed by the important standardising bodies. This

apparatus may be used in tests the results of which must be agreed by two parties often thought to have opposed interests, e.g. buyer and seller, where disputes may be reduced to a minimum by the use of apparatus and of procedure mutually agreed. In these cases I believe that there should be specified such apparatus dimensions and details as will eliminate uncertainty in the accuracy of the results due to doubt as to apparatus construction. In broad terms it may be said that it is useless to specify a method of test without also closely specifying the apparatus employed in that method.

(b) *Research.* In research, the result is more important than the tools used to achieve it. Standardisation has, in this case, the incidental advantage of enabling the research worker to build up whatever equipment may be required and to effect replacements with the minimum of inconvenience.

(c) *Educational.* An abundant supply of inexpensive apparatus is the main requirement for educational use, without any particular desire for a rigid specification. A similar benefit, however, accrues to the educational user as to the research worker.

**Benefits of Standardisation**

The benefits, to the manufacturer, of wider standardisation may be summarised thus: (a) A reduction in diversity of types; (b) the manufacture of larger batches; (c) increased efficiency of production; (d) a larger output from a given number of man-hours; (e) a consequent lowering of costs; (f) a reduction of storage space in warehouses; (g) a better service to the user and a shorter delivery time.

**Standardising Bodies**

The main official bodies concerned with the publication of specifications for special types of apparatus are The British Standards Institution (B.S.I.), The Institute of Petroleum (I.P.), and The Standardisation of Tar Products Test Committee (S.T.P.T.C.).

The Air Ministry publishes D.T.D. specifications, and the Society of Public Analysts and the British Pharmacopoeia each promulgate some standards; but their volume is small in comparison with those of the other organisations. Standards are also issued by various Research Associations and Trade Associations the most important of which, in the laboratory apparatus field, is the British Laboratory Ware Association (B.L.W.A.).

**The B.L.W.A.**

The British Laboratory Ware Association represents manufacturing interests only and numbers among its members all the important laboratory furnishers in Great Britain. This Association has a technical committee, which is an autonomous Industry Committee of the B.S.I. It was formed in 1943; it holds monthly meetings and is concerned with all aspects of chemical apparatus design, function and specification. It delegates representatives to sit on the apparatus committees of the other bodies. It has so far issued about fifty standard blue prints of laboratory glassware, and twenty rationalisation schedules, but there is still a vast amount of work to be done.

In considering the design of laboratory glass condensers, for example, a survey showed that ninety-three different types were offered for sale by members throughout the country. The bulk of the demand was shown to be confined to a few types, which included the Thorpe's Inland Revenue Condenser. It was found practicable to reduce the number of different types listed by manufacturers to seven, without any inconvenience to users.

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Again, it was found that, taking the products of all the manufacturers in the country, 352 different types and sizes of beakers and flasks were available and that war-time production was being impeded by this great diversity. A careful analysis of the spread of the sales showed that it should be possible to reduce this number to 147. It was recognised, however, that some of the non-rationalised sizes might have been standardised in some works' methods and that inconvenience would result if the non-rationalised sizes were to be withdrawn from manufacture. It was therefore agreed in conjunction with the manufacturers, to encourage the use of the 147 sizes by using heavy type for their catalogue descriptions, to try to offer better delivery of these sizes and thus to canalise the demand, and to review the position in due course. A certain measure of success has attended these efforts, but the natural conservatism of a highly individualistic class of chemical user still finds a clamant voice.

Other types of apparatus which have been dealt with by rationalisation include Soxhlet apparatus, dropping, separating and filtering funnels, calcium chloride tubes, gas absorption tubes, porcelain-ware, specimen and test tubes, thermometers and Orsat apparatus. The Orsat apparatus illustrates one of the difficulties attendant upon all standardising work. It was recognised that from interchangeability of Orsat glassware, e.g. stop-cock rails, absorption pipettes, etc., great convenience would result to users who purchased replacement parts from different sources. The B.L.W.A. therefore prepared a design which, as an Industry Committee of the B.S.I., it passed to that organisation for consideration in the preparation of a British Standard. The B.S.I. deputed Committee SFE/17/2

(Methods of Analysis for Flue Gases) to include the Orsat design in its programme of work. The members of this committee condemned the use of a palladium - asbestos tube for the determination of combustibles, on the grounds that the method is inaccurate and that if these constituents are to be determined a Haldane apparatus, which is also included in its programme, should be employed. The B.L.W.A. provision for a palladium-asbestos tube was therefore withdrawn. Yet there is a sufficient demand for the palladium-asbestos tube in the smaller type of works to justify its manufacture. The difficulty arises that if the SFE/17/2 committee insists on the absence of the tube, manufacturers will continue to make Orsats into which the tube can be fitted between the stopcock rail and the absorption pipette and so will be committed either to making two types, or to refusing to make the British Standard type. Another sub-committee has now been appointed to reconcile the the two points of view.

It is hoped that these examples are sufficient to illustrate some of the problems involved in this kind of standardisation and to establish that no high-handed "monopolistic regimentation" is being carried out.

**Conclusion**

Enough has now been said to show that the standardisation of a wide variety of chemical apparatus is actively in hand; that dependence of this country on Germany as a source of supply for chemical apparatus has largely been overcome and that the United Kingdom has a vigorous laboratory apparatus industry alive to the need for improvement; that co-operation between the standardising bodies is close; and that benefits to both maker and user accrue from standardisation.

It is altogether to the good that the work which is being done should be more widely known. There is a great body of knowledge and experience among the scientists of the country, which can be brought to bear upon the question of apparatus designs, so as to effect improvements upon traditional types and assist the production of better, more efficient and standardised chemical apparatus.

## CLAY PIPES

NOW in Canada where he will take up duty with a subsidiary of his former firm Mr. Matthew Freer Rodger will carry the clay pipe banner to Canada. As a director of D. McDougall and Co. Ltd. of Charles Street, Glasgow, and their associate the Garteraig Fireclay Co. Ltd., Mr. Rodger was very much interested in the manufacture of clay pipes and in Canada will continue to take an active interest in this and other products of the group.

D. McDougall and Co. Ltd. are probably the biggest pipemaking firm in the world in so far as clays are concerned and recently celebrated 100 years of trading. At present the firm produces something like 40,000 pipes a week of which some 32,000 go to export markets. Mr. Rodger will settle at Montreal where the Canadian subsidiary has offices.

Canada and the U.S.A. are incidentally still very interested in clay pipes and a very substantial part of the Glasgow output goes to these markets. Recently some pipes came to light in the foundations of an American steel plant and were traced to Glasgow showing that then, as now, the American clay pipe enthusiasts drew their supplies from this old established Glasgow factory.

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**"Time for passage of Material through Rotary Kilns." By R. W. Pickering, F. Feakes and M. L. Fitzgerald.**—An expression is developed for the passage of material through rotating cylindrical kilns or dryers, relating the time of passage to the other important variables—slope, length, diameter, and rate of rotation of the kiln, feed rate and rill angle of the material. The expression is derived from fundamentals, and is in accord with previously published empirical relations. It is thought that the derivation will promote a better understanding of the mechanism of the movement of materials in rotary kilns and dryers. (*J. App. Chem.* 1st January, 1951, 13/19.)

# Refractory Materials in Gas Making Plant

*By*

**T. M. FIRKIN**

AN objective that both refractories producers and consumers should pursue is a study of the varying conditions and complex factors affecting the life of refractories in furnaces, retorts, etc., so that from the data thus obtained the manufacturer may be enabled to improve his product and the consumer increase the efficiency of his plant thereby.

To ensure their use to best advantage it is desirable that the manufacturers of refractories have as wide a knowledge as possible of the consumer's process, plant and conditions generally, but it is obviously impossible for him to have the necessary intimate knowledge of the conditions which exist in each of the multitude of modern industries which he serves.

### A Spirit of Enquiry

This paper, therefore, is prepared in a spirit of enquiry. It is proposed to present some general notes and information on such refractory materials as are commonly used in gas making plant in the hope that these may prove of interest and assistance, and the members of the Australian Gas Institute, as experts in the production and use of gas will bring forward experiences, enquiries and I trust promote discussion, that should prove of interest and benefit to all.

The refractories used in major portion of gas retort installations including both vertical and horizontal, are, almost invariably of a highly siliceous composition, the main reason for this being that this type of material is less prone to shrinkage in continued use than the more aluminous materials, and moreover is resistant to the corrosive and erosive action of salty coals when steaming is employed.

### Types in General Use

Two main siliceous types of refractory in general use, are silica and highly siliceous fire clay.

"Silica" material is defined by the Institution of Gas Engineers as "containing 92 per cent. and upwards of silica," and is universally understood as a refractory made from quartzite of suitable quality and structure, which is crushed, ground and mixed whilst wet with 2-2·5 per cent. lime, and, after drying, kilned to a temperature of a least 1,425° C.

Silica refractories as distinct from siliceous are characterised by a high melting point (1,725° C.), high mechanical strength, good thermal conductivity, and, what is perhaps their outstanding feature, a rigidity under an applied load almost to their melting point. All of these are desirable properties when considered as a structural material for gas retorts, and permit of high operating temperatures.

However, silica has peculiar properties as regards expansion and thermal spalling and the successful use is dependent on a knowledge of these.

Paper to the Australian Gas Institute, presented at the 1950 Conference.

Silica is polymorphous, that is to say, it has the ability to exist in different crystalline forms, actually seven in number. There are three types, viz., quartz, cristobalite and tridymite, and of these quartz and cristobalite can occur each in two phases, $\alpha$ and $\beta$, and tridymite in three, $\alpha$, $\beta_1$ and $\beta_2$. These phases change (or invert) from one to another at various temperatures, and the inversions are all attended by volume changes.

The temperatures at which the main changes occur are shown in the following table:

| *Inversion* | *Temp.* | *Rate of inversion* |
|---|---|---|
| $\alpha$ Quartz $\longleftrightarrow$ $\beta$ Quartz ... ... | 573° C. | Rapid |
| $\beta$ Quartz $\longrightarrow$ $\beta$ Tridymite ... ... | 870° C. | Slow |
| $\beta$ Quartz $\longrightarrow$ $\beta$ Cristobalite ... ... | 1,000° C. | Slow |
| $\beta$ Tridymite $\longrightarrow$ $\beta$ Cristobalite ... | 1,470° C. | Slow |
| $\alpha$ Cristobalite $\longleftrightarrow$ $\beta$ Cristobalite ... | 230° C. | Rapid |
| $\alpha$ Tridymite $\longleftrightarrow$ $\beta$ Tridymite ... | 117° C. | Rapid |

It will be noticed that the inversion from the $\alpha$ form to the $\beta$ form of each modification is of the rapid type, and is so well defined that the $\alpha$ and $\beta$ modification will only exist within their own temperature ranges.

In the case of the slow types, the slowness of inversion permits the various modifications to exist for considerable periods of time in unstable forms at temperatures outside the range of their ability.

**Permanent Expansion**

Now in the manufacture of silica refractories, the silica before firing is in the form of $\alpha$ quartz, and as the temperature of the kiln is increased this changes at a temperature of 573° C. to $\beta$ quartz with an expansion of approximately 0·3 per cent. linear. As the heating is continued the $\beta$ quartz begins to change to $\beta$ tridymite and $\beta$ cristobalite and as the changes are of the "slow" or "sluggish" type, the proportion of each of the minerals developed is a function of time, temperature, and fineness of grinding.

On cooling the silica minerals developed when hot as the $\beta$ will change to the $\alpha$ types, that is $\beta$ cristobalite will change to $\alpha$ cristobalite, $\beta$ tridymite to $\alpha$ tridymite, and $\beta$ quartz to $\alpha$ quartz, so that, a cold silica refractory consists of a mixture of $\alpha$ cristobalite, $\alpha$ tridymite and probably a small percentage of unchanged $\alpha$ quartz.

The true specific gravity or density of these three minerals are:

| | |
|---|---|
| Quartz ... ... ... | 2·65 |
| Tridymite ... ... ... | 2·27 |
| Cristobalite ... ... | 2·32 |

It is obvious, therefore, that in changing from quartz, with true specific gravity of 2·65 to tridymite and cristobalite with 2·27 and 2·32 respectively, a considerable increase in volume has occurred, and this is generally referred to as "Permanent Expansion," and is quite distinct from the ordinary "thermal" or "reversible" expansion. The manufacturer allows for this permanent expansion during the manufacture of bricks and shapes, by making the moulds used smaller than the finished brick at the rate of approximately $\frac{1}{2}$ in. per ft.

If during the kilning process the treatment has been insufficient to ensure that all of the "permanent" expansion is completed, this is likely to occur when the bricks built in to furnace or retort structures, are heated to temperatures exceeding 1,200° C. and in such cases serious damage and shattering of the furnace may result.

**Standard Specification**

This "growth" has in the past been the cause of great concern in gas making plant and is the reason for Clause 5 in the Standard Specifications of the Institution of Gas Engineers. This clause seeks to

control the "after expansion" by specifying that "permanent expansion" determined in an accelerated simulative service test, does not exceed a very small value (0·5 per cent.).

It is difficult to understand why, in the same specification, a maximum value for true specific gravity is not specified, as this is probably the best means of determining the liability of silica refractories to "permanent expansion."

Some specifications call for a maximum value of 2·35 or 2·36, and the silica refractories where true specific gravity is in excess of these values should not be used for gas retort structures.

Actually, practically all silica bricks supplied in Australia have a value of between 2·32 and 2·34 and material such as this will give no trouble with "after expansion."

**Reversible Expansion**

The thermal or reversible expansion is quite distinct from the permanent expansion, is definitely known, and hence due allowance can be made for it where necessary during construction. The expansion is not even and is the composite of the changes in volume on heating of the three forms of silica present, viz., cristobalite, tridymite and probably residual quartz, when changing from the $\alpha$ form to the $\beta$, and usually amounts to approximately 1·2 per cent. linear at 1,400° C. Since the majority of the silica is present as cristobalite the bulk of the thermal expansion occurs at the transformation range for that material, approximately 230° C.

The expansion curve of well burned silica brick is shown in Fig. 1, and amounts to approximately 1·2 per cent. at 1,400° C.

It is evident from the curve, that

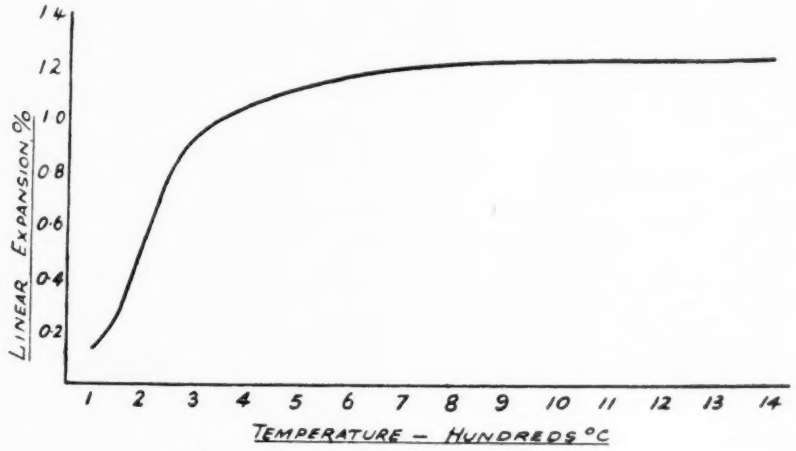


Fig. 1. Thermal expansion curve for silica

in order to prevent spalling or internal strains, it is essential that when heating up new silica constructions, or old constructions that have been cooled down that the heating be carefully controlled until a temperature of at least 650° C. is reached. Moreover the heating must be even. On being cooled there is a corresponding shrinkage to the original volume, and so similar care must be exercised between 650° C. and atmospheric temperature. It is not generally appreciated that, whilst silica is sensitive at these comparatively low temperatures, at

elevated temperatures it is quite a spall resistant material.

**Restriction on Use**

Now whilst it is generally appreciated that the use of silica for the construction of gas retorts and coke ovens gives a longer life, permits of higher operating temperature and therefore greater throughput, and affords better resistance to the erosion of salty coals, especially when heavy steaming is practised, the irregular and comparatively high thermal expansion, with the attendant difficulties in making provision for this, together with the liability to spalling at low temperatures if due care is not taken, restricts its use to a great extent.

Highly siliceous firebrick is used very widely as a material approaching as nearly as is practicable to the composition of, but without some of the shortcomings of silica.

Such refractories are made from either naturally occurring or mechanically mixed silica in the form of quartz and fire clay, and are defined by the I.G.E. as "containing more than 78 but not more than 92 per cent. of silica." These after suitable grinding, blending and shaping are kilned to give a product of good texture and hardness, but in which the inversion of the quartz to cristobalite has progressed to only a very small degree. In fact the true specific gravity of these siliceous materials, whilst varying somewhat, are generally in the range of 2·47-2·55.

**Growth During Kilning**

During kilning there may be a slight growth of the brick, this in the case of one product amounting to some $\frac{3}{16}$ in. per ft. linear. It may be expected that subsequent use for prolonged periods at gas making temperatures would result in "growth" or "after expansion" as in the case of incompletely inverted silica bricks. This does not occur, and several brands of English and Australian bricks in this class, show, after reheating at 1,410° C. for 2 hr. as specified by the Institution of Gas Engineers, a slight expansion of only 0·2 per cent.

The reasons for this lack of growth are probably first, that the silica as quartz instead of quartzite and without the lime flux, is very slow in inverting to cristobalite, and secondly, that any slow growth of the silica component is counteracted by shrinkage of the clay component of the mixture.

**Advantages of Siliceous Material**

Now as stated earlier the real advantages of siliceous material over silica are the lesser sensitivity to spalling at low temperatures and a lower thermal expansion. Since the quartz has, to a great extent, remained unchanged, the siliceous refractory behaves more or less as quartz. Thus the thermal expansion curve is fairly regular and amounts to only 0·7-0·8 per cent. linear at 1,000° C. This evenness of expansion also accounts for the lesser sensitivity to spalling than silica.

However, when comparing the refractory values of the two types, it is found that the clay bonded siliceous type has a much lower "Refractoriness under Load" value than silica, and hence the higher operating temperatures available with silica are not permissible with "siliceous."

Thus of these two materials, which comprise the major portion of gas making retorts, there is silica which is preferable for thermal conductivity (and hence throughput), for hardness (to resist abrasion of the moving charge), for resistance to erosion (in the lower portion of the retorts caused by steaming), and which allows higher combustion chamber temperatures. On the other hand, there is "siliceous" and "semi-silica" which overcome the two shortcomings of "silica," viz.,

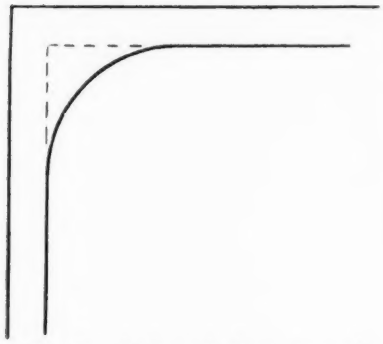

Fig. 2. Isothermal lines exposed corner heated on two faces

liability to spalling at low temperatures and difficult thermal expansion, and still maintain to a good extent the thermal conductivity of silica.

**Requirements for Retorts**

For the upper and lower section of vertical retorts a material not necessarily of high refractoriness, but of good abrasion resistance, and not prone to excessive spalling is required. Such materials are specially made for these positions where resistance to the abrasion of the incoming cold coal and the outgoing hot coke is the all important factor.

Wall linings of retort settings are generally made from material of similar expansion characteristics as the retorts.

The four main destructive forces which affect refractory materials in gas retorts are: Spalling, Flaking, Fusion, Erosion.

**Spalling**

Spalling can be classified in three main types:

1. Thermal Spalling.
2. Mechanical Spalling.
3. Structural Spalling.

Thermal spalling is mainly that caused by rapidity and range of thermal fluctuations, in addition to the irregular thermal expansion characteristics such as those discussed earlier in this paper.

It is due to the fact that in line with most other materials, refractories expand on heating and contract on cooling. It is obvious that when a block is heated unevenly, one part will expand more than another, setting up stresses which may or may not cause a rupture, depending on the physical properties of the materials used. As an example many arches have the bottom face very hot, whilst the outer face is relatively cool, and pinching of the hot face sometimes occurs.

Rapid cooling may result in cracking at right angles to the cooled

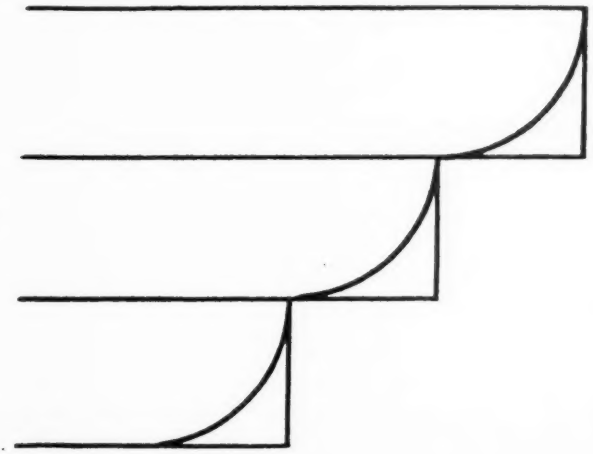

Fig. 3. Spalling effect on exposed corners of brickwork

surface, since this is then in tension. The more rapid the heating and cooling the more severe are the strains set up since the temperature gradient from the hot to the cold face is steeper.

**Simple Design the Rule**

It will be obvious from these foregoing remarks that the more intricate and the larger the shape the greater the stresses set up and so it is wiser in designing shapes and blocks to try and keep away from large and intricate shapes, irregular sections and sharp angles. These latter should where possible be provided with small radius fillets. A good rule to remember is, "The simpler the design, the more satisfactory the service."

Mechanical spalling is that in the main caused by rapid heating of wet brick, abuse in removing clinker, and in the case of gas retorts of scurf.

Structural spalling is caused by insufficient provision for expansion —resulting in pinching, badly designed shapes or structures, exposed joints, etc., and in regard to these latter two I feel that their importance is not generally appreciated. Figure 2 gives an indication of the isothermal planes found in the exposed corners of rectangular solids. It will be noted that isothermal plane is rounded off. Exposed corners of brickwork are quite subject to spalling and should be avoided wherever possible. The effect of exposed corners is shown in Fig. 3.

Again, the methods of installing refractories controls to some degree the heat and slag penetration. In a furnace wall laid dry or where joints have become open because the jointing has either fallen out or fretted away, the isothermal lines are determined by the heat penetration both from the surface exposed to the high temperature and to the surface exposed to the heat which penetrated between the bricks. Fig. 4 shows what happens in this case. Consider a plane surface through portion of the wall, showing the ends of the brick exposed to the furnace atmosphere. Heat penetrated each brick in this plane from three sides and the isothermal lines in this plane will be curved in the manner shown by the dashed lines. Since the coefficient of expansion determined the movement of the bricks the surface will tend to assume a curved shape shown in the dotted line. If there is insufficient resiliency in the material spalling will occur. The figure shows but one plane, and it is obvious that the isothermal surface actually tends to assume the shape of a hemisphere.

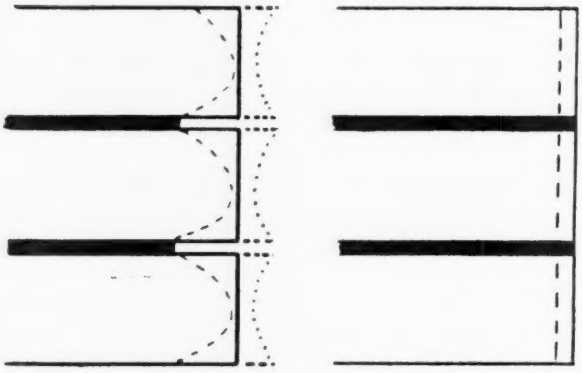

Fig. 4.
Left hand side, spalling caused by open joints.
Right hand side, well-bedded joints

On the other hand, bricks laid properly in cement approach the condition obtained in a monolithic wall. The isothermal lines in this plane are parallel to the exposed surface of the wall and there is not tendency to attain a shape differing from the original. The tendency towards spalling is therefore minimised.

**Flaking**

This is a disintegration of the surface of the refractory sometimes found on the inner face in vertical retorts. The condition is generally peculiar to these retorts, and not regularly met in other industries. It is generally considered to be associated with scurf adhesion, or the removal of scurf. During the operation localised high temperatures can be reached, thus subjecting the face of the brickwork to rapid temperature fluctuations. This surface is also likely to become saturated with low fusion point impurities from the coal and coke, causing a difference in composition and an expansion differential between the surface layer and the parent brick. Such a condition can cause "flaking."

**Fusion**

Fusion or softening of the refractories is caused by temperatures in excess of those at which they can be safely used. It can be pointed out here that in gas retorts where the whole of the wall from front to back is at a high temperature, making conditions more severe than in the ordinary type of furnace where generally but one face of the brickwork is exposed to the maximum temperature, thus allowing the cooler portion of the wall to effectively carry any load.

However, the permissible temperature for most of the refractory materials used are fairly generally known in the gas industry and fusion or softening under load are not very often encountered.

The erosion of vertical gas retorts in the lower sections is generally agreed to be caused by the combined action of steam and impurities from the coal on the retort walls and appears to be in proportion to the amount of steam introduced. Thus in plants where heavier steaming of retorts is practised, greater erosion is experienced. It is not proposed to discuss here the reason for this erosion, but rather to indicate that generally refractories high in silica content are more resistant to this destructive influence. Silica material appears to resist the action more effectively than the siliceous and semi-silica varieties, although the latter type is said to be very effective in England.

**Materials for Ancillary Plant**

No attempt has been made to describe any of the refractory materials used in ancillary plant such as boilers, etc., and in the gas-fired industrial furnaces very often designed and maintained by the staff of gas undertakings. Most of these materials including the high alumina, kyanite (mullite or sillimanite) materials are sufficiently well known and proven.

The thermal insulating materials available today include the well-known low temperature insulation made from diatomaceous earth, and still is the most efficient insulation from the point of view of use at medium temperatures not exceeding 1,000° C.

For higher temperatures cellular fire clay material is available, the insulating efficiency of this being in inverse ratio to the bulk density.

Of interest to note with this type of material are the "Gas Permeable Refractories" developed in England during recent years. These have a density as low as 30 lb. per c. ft., their purpose being the construction of gas-fired furnaces where their high permeability allows the products of combustion to leave the

furnace through the walls, thus eliminating flues and exit ports and increasing the thermal efficiency of the furnace.

**Bonding and Jointing**

A paper such as this would be incomplete without making some mention of bonding materials and jointing cements.

These form a very important part of any refractory installation. They should always be selected with care, paying due attention to the fineness of grinding and operating conditions of the retort. Poorly made, or excessive joints, or improper jointing material can shorten the life of a structure. As a general rule the mortar material selected should be of the same composition as the brick with which it is to be used. However, for some repair and patching work cold setting mortars are often to be preferred, these having the advantage of adhering to the brickwork.

This brings to a conclusion what I realise is a brief and inadequate talk on this subject. As suggested in my opening remarks, the paper is tendered in a spirit of inquiry, and if it promotes some discussion amongst your members, then I feel the effort will have not been entirely in vain.

# BRITISH IRON AND STEEL RESEARCH ASSOCIATION

## Annual Report of Council

THE full report is available from the Association at 11 Park Lane, London, W.1., but the following extracts will be of general interest.

**Blast Furnace Process Committee**

The field trials team have continued to exploit techniques for blast-furnace exploration, and studies of the stock-line contours and rates of descent have been made at three works; it remains difficult to give a generalised interpretation of processes from this work as local variations exert a considerable influence on furnace working. The use of radio-active tracers in the furnace has been extended to include Cobalt 60, a relatively inexpensive isotope with a half-life of 5·3 years, which can be introduced into the burden. It can give a figure for the total time of burden descent (shown by the appearance of radio-activity at casting). It has also been introduced into refractories while lining the furnace, to give an estimate of the rate of wear. This is indicated by the disappearance of radio-activity, measured from a point outside the furnace opposite the "tagged" bricks. These techniques are being improved and much experience has been gained from installations in the linings of furnaces at five different works.

Lime has been injected through the tuyeres of a blast furnace. Results show substantial, though not complete, control of slag basicity. Knowledge of the gas flow pattern at the tuyere zone is being increased by experiments on models at the Physics Department, and a traverse of temperatures in the blow-pipes was made at the request of a member firm. Proposed extensions of work on the tuyere region include the injection of various fuels and fine ores, and sampling and photographs of the combustion zone.

Work on reduction of lump ores was completed by the examination of limey Frodingham, green Northants, raw Cleveland, Gellivare, Keloucha and Konakry ores. The results have been published; the broad conclusion is that it is possible to classify ores into two groups, of which one would require crushing to about 1½ in. to

avoid excessive direct reduction, while the other only needs to be reduced in size to 4-3 in. lumps.

**Heat-Balances of Furnaces**

Study of heat-balances of furnaces has progressed by the construction of a "heat-balance computer," which, working on a multiple slide-rule principle and utilising certain empirical assumptions, will enable the heat requirements of the various burden constituents and the heat available in the ascending gas to be read off. These values can be directly transferred into graphical form.

In the laboratory, the kinetics of the reaction above 1,400° C. of carbon in liquid iron with ferrous oxide and magnetite have been studied. The technique includes use of a spinning crucible and induction heating of the liquid iron in fused magnesia crucibles, which avoids attack of the refractory by oxides. The very rapid reactions are followed by cine-photographs of low inertia instruments. Results were obtained for rate, order, temperature coefficient and activation energy of the reaction: they show that the reaction rate of (FeO + [C]) is unlikely to be a controlling factor in the overall reduction process. Apparatus is being assembled for the study of reactions in the system CO—$CO_2$—C—$Fe_xO_y$—Fe, in the temperature range 900°1,100° C.

Important extensions of the technique of differential thermal analysis (which is used to identify minerals in rocks) have been made during work on iron-bearing clays, when it was found that oxidation changes gave uncertain results. These necessitated the use of controlled atmospheres, oxidising, reducing, or neutral, and thermal curves for many iron-bearing minerals are being re-determined. The new technique can be modified for the study of coke reactivities, reducibility of ores, and reactions during sintering; results for various forms of carbon, including wet and dry quenched coke, have been obtained.

**Blast Furnace Practice Committee**

Some further work has been carried out on the examination of furnace data by the "scrap-free smelting ratio" method, and all the data have been examined by the Physics Department. It has been confirmed that there is a statistical justification for assuming a linear relation between the "smelting ratio" and gross burden for a number of results from selected works operating under similar conditions. Statistical work with the "rapid computer" at Imperial College has also progressed, and an estimate has been obtained of the relative influence of several process variables on the furnace performance. The progress of the whole work is to be reported, with a view to presentation to the Blast Furnace Conference.

Magneto-striction methods of producing ultrasonic pulses have been incorporated in apparatus for trials of a stockline recorder in a full scale furnace. Satisfactory representation of the stockline was obtained with blast off the furnace, but the difficulties due to dust interference and temperature variations of the gas have shown that it is not practicable to devise a satisfactory ultrasonic recorder with present methods. Attention is being given to new developments in radar technique with a view to possible future application to stockline recording.

**Co-operation with Infra-Red Development Co.**

Co-operation has continued with the Infra-Red Development Co. Ltd., on the problem of continuously recording the values of CO and $CO_2$ in the top gas. The instruments were sufficiently developed for use during the one-week study period on the Consett furnace, but are not yet ready for full industrial application, because of difficulties in maintaining a constant and representative flow of gas for long periods.

The Third Junior Blast Furnace Conference, held at Ashorne Hill in October was well attended. Papers were presented on "The Layout of Blast Furnace Plant, with particular reference to the Handling of Raw Materials and Products," and "The Routine Duties of the Junior Blast Furnace Operator," and were followed by lively discussion. Members of the B.I.S.R.A. staff described jet casting for taphole opening, the use of Cobalt 60 for detecting refractory wear, and the geological formation of iron ores. The rotating-disc gas cleaner, and an instrument for converting circular

charts to a linear form were demonstrated.

In view of the number of breakouts which have recently occurred, the Committee held an informal discussion on this subject to which several other operators were invited.

### Blast Furnace Refractories Joint Committee

This Committee has continued joint supervision of the work carried out by the British Ceramic Research Association. The practical work largely consists of examinations of blown-out furnace linings. Vitrification due to oxidation of iron or iron penetration has been revealed, and the effect of irregularity of furnace working on the progress of CO attack, and of stable temperature stratifications of the blast on refractory wear, have been investigated. Laboratory work has continued on the state of oxidation of evenly distributed iron materials in clays fired at various temperatures.

In answer to requests from the Blast Furnace Practice Committee, a considerable number of taphole clays have been examined in attempts to elucidate the desirable properties of a good clay. Several tests have been employed, but it is difficult to draw general conclusions from them. Consequently, trials at works of some member firms are in progress, particularly at the Shelton Iron, Steel and Coal Co. Ltd., where B.I.S.R.A. staff have been assisting in an attempt to ascertain the degree of firing of the clay in various positions in the taphole, by examination of the temperature and state of the clay.

The Eighteenth Blast Furnace Conference, held at Ashorne Hill in May, proved to be a further addition to the series of successful meetings on refractory materials. The results of the work on taphole clays were presented, and in the following sessions papers were read on two newly developed materials for blast furnace linings, namely carbon and china clay.

### Steelmaking Refractories Joint Committee

General agreement has been reached on the choice of raw materials for roof quality chrome-magnesite and on the manufacture of these refractories. The all-basic furnace trials have shown that bricks of British manufacture are satisfactory; output rates considerably higher than those obtained with silica roofs and high roof lives have been obtained, though there are not yet sufficient data to make a definite statement on the economic aspect.

A statement prepared by the Casting Pit Refractories Sub-Committee on standard sizes of certain casting pit refractories has been submitted to the British Standards Institution.

### Refractories Section

As in previous years the section has collaborated with the British Ceramic Research Association and with steel and refractory manufacturers through the Joint Refractories Committees. A beginning has been made on the laboratory manufacture of special refractory ware and on the development of petrographic techniques for the study of slags and refractories.

### The All-Basic Open Hearth Furnace

Since the formation of the All-Basic Furnace Sub-Committee, seven trials have been completed and three more are still in progress. Of the seven completed, three have given results which, until conditions can be improved, have discouraged further experiment in the plants concerned, three have shown an average furnace life which, with the increased rate of output, justifies adoption as a standard practice, and one on the largest (150 ton) furnace has given results which justify further trials.

While comment is premature on the current trials, one furnace is giving a very high average weekly output (30 per cent. greater than with the normal silica roof) and seems likely to have an equally impressive life.

These trials show the potentialities of the all-basic furnace and confirm the necessity to maintain the furnace hot. They also indicate the suitability of the Committee's recommended roof design and of the use of sea-water magnesia as a raw material. With supplies of Turkish chrome now assured the extension of basic roof practice is possible.

A factor militating against possible maximum output rates from an all-

basic furnace is inadequate charging capacity. To this may be added bad checker condition. The use of creosote pitch for fuel appears to reduce the life of basic roofs. Trials over a period of 2 years show that fuel consumption is roughly the same as that with a normal silica roof and not greater, as has been reported elsewhere.

**Open Hearth Refractories Testing**

An *ad hoc* Sub-Committee, formed by the Steelmaking Refractories Joint Committee to examine the possibility of designing an apparatus to assess bricks for open-hearth roof service, has worked out a plan which has been approved by the parent Committee. The apparatus has been recommended not only for testing bricks but for studying the effects of operating conditions on a given brick. In principle it is a furnace in which a roof panel of the refractory under test can be subjected to controlled conditions of temperature, gas flow, dust concentration, etc.

**Casting Pit Refractories**

Work has continued on standardisation of refractories for casting pits and an investigation is in progress in the British Ceramic Research Association on the coring of these materials. Consideration has been given to the development of large basic lined iron ladles to increase the efficiency of the soda ash desulphurisation process.

**Electric Furnace Refractories**

Discussions for co-operation between the Electric Furnace Refractories Joint Sub-Committee and the Electric Furnace Process Committee have taken place.

Refractories taken from various places in the roof, side-walls and hearth of electric furnaces after being in service are being compared in the B.Ceram.R.A. laboratories with open hearth roof bricks.

Data have been accumulated on operating conditions, design characteristics and refractories consumption in electric arc furnaces.

**Steel Foundry Refractories**

Agreed methods of collecting data on steel foundry melting units have been worked out. As yet only the acid electric furnace has been fully covered, but a considerable amount of information from converters and cupolas has been acquired.

The strain-gauge electronic recording system to weigh a side-blown converter to assess refractory wear has been found to have an undesirably high degree of error. Plans are being made to overcome this.

The work on water cooling in the cupola is being held over until it can be carried out in the Steel Castings Division's pilot plant at Sheffield.

**Laboratory Refractories**

A report has been prepared to provide background information for the small-scale production of highly refractory laboratory ware and to supply a convenient collection of data on the properties of many highly refractory materials with melting points in the region of 1,800° C. and above. In the laboratory, slip casting, tamping and pressing techniques have been developed and a high temperature kiln is under construction.

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## STURTEVANT ENGINEERING CO. LTD.

WE have received from the above Company, Publication No. 9501 entitled "Crushing, Grinding, Screening, Separating, and Mixing Machinery." This publication supersedes No. 1502. It outlines their variety of crushers, including the roll-jaw coarse and fine crushers, rotary fine crushers, crushing rolls, swing sledge mills, hammer pulverisors, ring roll mills, vertical and horizontal disc mills and tube mills. Information is also provided on a rotary dryer for the rapid removal of moisture from large quantities of loose materials like coal, gypsum, sand, slag, stone and so on. A variety of screens such as the "Moto-Vibro" and the "Newago" are described as well as a Whirlwind air separator. Details are given of batch mixers and batch pounders and an automatic dust filter and crusher for coal sampling. A variety of laboratory equipment covering the above classes is also included.

This publication is complete with illustrations and a complete specification of the sizes, output, power requirements and so on for the various articles of equipment.

# Instrument Design—New Developments

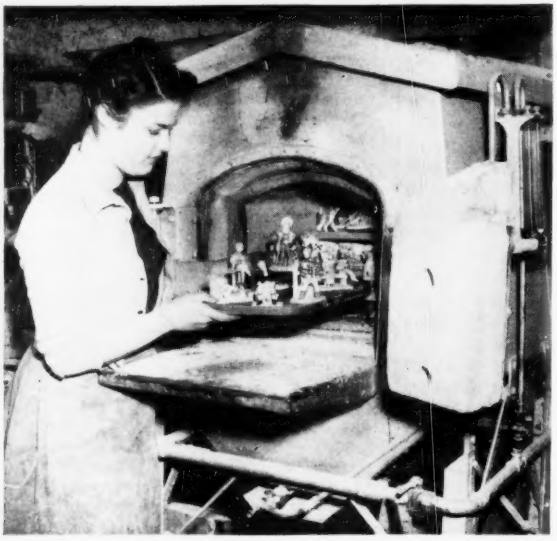
IN the field of industrial recording and controlling instruments, it is seldom that an established front-rank manufacturer is able to announce a wide and entirely new range. Generally, the improvements suggested by experience have to be worked, if possible, into existing patterns. Often they have to be shelved; there comes a time, therefore, when the instrument maker who seeks constantly to better his product feels that he must re-design.

The new "Series 500" are an advanced range of industrial control equipment manufactured by Bristol's of Weymouth. The series includes systems for the indication, recording, control, and telemetering of temperature, pressure, flow, liquid level, and humidity.

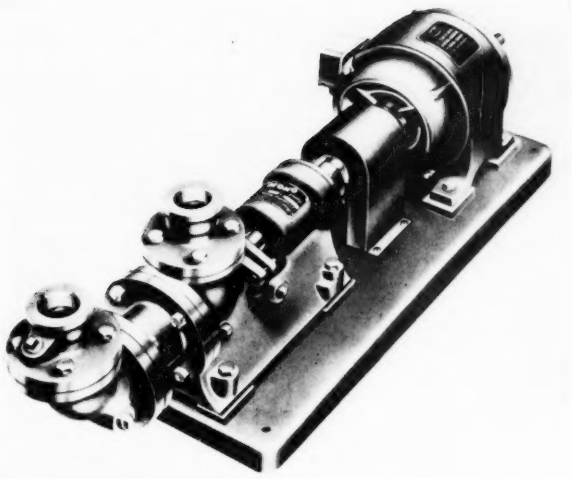
In the well-known type of pressure spring thermometer the primary element translates the temperature changes it experiences into pressure changes, which are transmitted through capillary tubing to a pressure spring measuring element in the instrument which moves a pen arm across a chart. This "pressure spring" is a helix of flat section tube that unwinds under internal pressure on the Bourdon principle. The movement is sufficiently large to make unnecessary any mechanical magnification other than that provided by a simple linkage to the pen arm, indicator needle, or controlling device.

The Series 500 controllers are air-operated, using the well-known Free Vane principle of automatic control, and require an air supply at 20 lb. per sq. in. The sensitive measuring system (as described for recorders) is used to move a small metal vane between two air jets. The air jets oppose one another in such a manner that the measuring element uses little or no power to accomplish control. The position of the metal vane relative to the jets determines the back-pressure in the jet system, which operates a capsule in a pilot valve or pneumatic relay. The pilot valve controls the flow of air to whatever pneumatic device the instrument is controlling, for example, a valve in a steam line.

For more complex control problems, "reset integral" control, in which an integrating action is added to the proportional action to compensate for load changes, or "derivative" characteristics where a correction proportional to the rate of change of the controlled variable, or a combination of these may be followed. These rates are adjustable, and the adjustment is calibrated, so that the effect of plant characteristics may be readily duplicated on other controllers. If desired, two independent control systems, or one controlling and one recording system, may be fitted into one case.



Unloading finished pottery from a gas-fired kiln of the type exhibited on the Gas Council stand at the British Industries Fair, Castle Bromwich. The kiln will take up to 200 pieces of pottery, or about 80 pottery figures for firing, and operates at a temperature of 1,060°-1,100° C. The figures in the photograph are characters from Alice in Wonderland and from Nursery Rhymes, similar to those which have been accepted for display at the Festival of Britain



The D4 Mono pump

## MONO PUMPS LTD.

RECENTLY as representative of the range of Mono pumps, the British Council of Industrial Design chose a D4 Mono pump as an example of British pump engineering practice. This is being displayed in the Power and Production Section on the South Bank site.

An A2 Mono pump is being used to supply oil to twelve smoke generators, situated at the top of the Mining Pavilion Tower on the South Bank site, whilst three H4 stainless steel Mono pumps are being used at the Festival Gardens at Battersea Park, London for transferring beer from road tankers and beer barrels to storage tanks.

## DURAX No. 3

WE have received a leaflet under the above title describing a refractory cement manufactured by General Refractories Ltd., Genefax House, Sheffield 10. Among the advantages claimed for Durax No. 3 as a jointing for firebricks is the minimising of joint weakness and infiltration of cool air through the shrinkage cracks, thus lowering the thermal efficiency of the furnace.

An aluminous refractory cement supplied in a finely powdered state it can be easily mixed with water to form a smooth paste. This is easily trowelled. Alternatively it can be made into a creamy consistency so that the bricks can be dipped.

Important properties are heat resistance—up to 1,710° C.—absence of shrinkage; tensile strength after firing at 1,500° C.—912 lb. per sq. in. Approximately one cwt. of Durax No. 3 will cover 200 sq. ft. of surface with two coats $\frac{1}{8\frac{1}{2}}$ in. thick.

## EXHAUST VENTILATION

WE have received from the Sturtevant Engineering Co. Ltd., Southern House, Cannon Street, E.C.4., a copy of their publication No. 3603 with the above title. It deals pictorially with a number of applications of their system including fume removal from furnaces, ovens and stoves, the handling of corrosion fumes in laboratories, electroplating shops, pickling shops and so on, the removal of steam in the textile and paper industries as well as from boiling pans.

Other applications include fume and vapour removal in baking ovens and industrial kitchens.

Details are also provided of the Sturtevant Spray Booth Exhaust system for the finishing industry. Copies available to those interested.

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## THE BRITISH CERAMIC SOCIETY

THE next meeting of the section will be held at the Midland Hotel, Manchester, on 11th July, 1951. The date has been chosen to accord with the meeting of the Northern Brick Federation and Affiliated Associations to be held at the same place on the following day. The programme is as follows:

9.30 a.m. Meeting of Section Council.
10.0 a.m. General meeting of Section.
10.15 a.m. The paper "Power Plant for the Heavy Clay Industries" by John Fox will be read and discussed.
11.5 a.m. The paper "The Attack of Kiln Flues by Sulphur-laden Gases" by F. Catchpole will be read and discussed.
11.55 a.m. A talk on "Gas Flow in Kilns" by I. M. D. Halliday will be given and discussed.
12.45 p.m. Conclusion of Meeting.

After lunch the directors of J. and A. Jackson Ltd., have kindly invited members to visit their works at Longsight and at Chadderton. A motor coach will leave the Midland Hotel at 2.0 p.m. for those who state they require it.

Information from F. H. Clews, Hon. Section Secretary, The Mellor Laboratories, Hanley, Stoke-on-Trent.

## OVENS AND FURNACES

A VERY useful pamphlet entitled "Standards for Class A Ovens and Furnaces 1950" has been issued by the National Fire Protection Association, 60 Batterymarch, Boston 10, Massachusetts, U.S.A., at 75 cents. The pamphlet deals with design data for oven safety, their location and construction, and various heating systems including steam, electricity, oil and gas, and ventilation. Space is devoted to safety control equipment and methods for fire protection.

## ADVERTISERS' INDEX

Acheson Colloids Ltd. ... ... —
Amalgams Co. Ltd., The ... 197
Applied Heat Co. Ltd., The ... —
August's Ltd. ... ... ... 176
B.U. Supplies and Machinery Co. Ltd. ... ... ... ... —
Bennis Mechanisations Ltd. ... —
Berk, F. W. and Co. Ltd. ... 207
Bradley and Craven Ltd. *Cover* i
British Ceramic Service Co. Ltd. The ... ... ... *Cover* iii
Carborundum Co. Ltd., The ... —
Casburt Ltd. ... ... ... —
Davies, James (Burslem) Ltd. ... 211
Fel Electric Ltd. ... ... ... 205
Gibbons Bros. Ltd. ... *Cover* ii
International Furnace Equipment Co. Ltd., The ... ... ... 187
Kent, James Ltd. ... ... ... 185
Lafarge Aluminous Cement Co. Ltd. ... ... ... ... —
Malkin, F. and Co. Ltd. ... ... 203
Mechanical Equipment Ltd. ... —
Mirlees Watson Co. Ltd., The ... —
Mitchell, L. A. Ltd. ... ... —
Mono Pumps Ltd. ... ... 174
Podmore, W. and Sons Ltd. ... —
Potteries Ventilating and Heating Co. ... ... ... ... 209
Protolite Ltd. ... ... ... 213
Rawdon Ltd. ... ... *Cover* iv
Royce, James Electric Furnaces Ltd. ... ... ... ... —
Service (Engineers) Ltd. ... ... —
Stewarts (Hanley) Ltd. ... ... 195
Webcot Ltd. ... ... ... —

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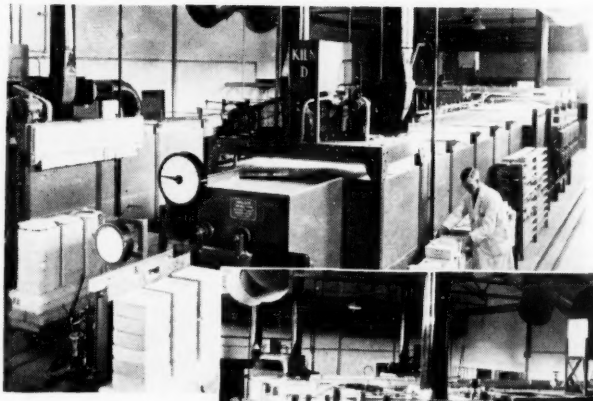

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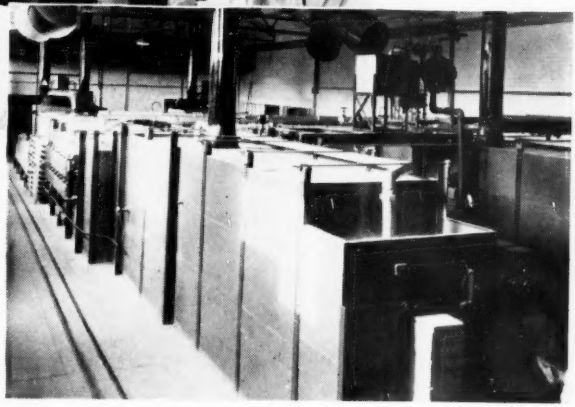

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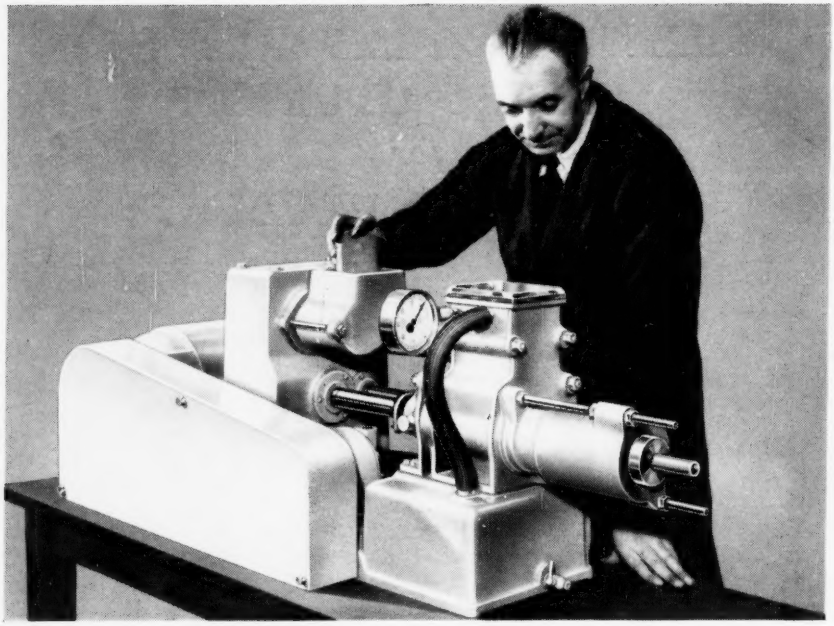

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